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THE EFFECT OF DEFENSE CONTRACTING REQUIREMENTS ON JUST-IN-TIME IMPLEMENTATION

by

Carl Ross Templin

A Dissertation Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

ARIZONA STATE UNIVERSITY

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THE EFFECT OF DEFENSE CONTRACTING REQUIREMENTS

ON JUST-IN-TIME IMPLEMENTATION

by

Carl Ross Templin

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ABSTRACT

This study examined the impact of defense contracting practices on defense contractors' efforts to improve production and purchasing operations by adopting the just-in-time (JIT) philosophy, a systematic approach of continual improvement. A conceptual model, based on transaction cost economics, was used to describe the buyer/seller relationship. This was defined in terms of cost uncertainty, contract uncertainty, asset specialization, and resource commitment. The research sought to identify the significant contracting elements that determine the level of government administrative control and their impact on JIT implementation. It also sought to identify linkages between government contracting practices and a firm's JIT activities. Data were collected by structured interviews with representatives from five defense electronics firms implementing JIT.

The research found the companies studied were generally free to implement most JIT activities with little or no government restrictions. However, government controls over specifications, quality requirements, and subcontracting activities emerged as serious limitations to JIT production and purchasing efforts. The government's purchasing policies and auditing practices restrict purchasing, somewhat, in establishing the close supplier partnerships required by JIT. Defense contractors were successful in finding ways to implement JIT production and purchasing to a considerable degree. However, they were not very successful in reducing documentation requirements and tried very little to change government policies and practices not supportive of JIT.

Concerning the impact of the contractual relationship, specialized asset requirements (quality requirements), as hypothesized, were the most significant determinants of the impact of government controls on JIT efforts, and the extent of JIT production implementation. Cost uncertainty (cost sharing arrangements), had a moderate but positive impact to JIT implementation, opposite to that anticipated. Resource commitment (use of government financing) was also a significant factor in JIT implementation. Companies who used such financing had their JIT production and purchasing efforts negatively impacted. The role of

contract uncertainty was weakest and had mixed effects. Difficult negotiations prior to contract award positively impacted JIT production but negatively impacted JIT purchasing. Difficult negotiations to make contract changes negatively impacted production and purchasing.

DEDICATION

I dedicate this dissertation to mw wife, Shirley, and our five children: Allen, David, Aaron, Angela, and Joshua. Their total support and willingness to sacrifice made this dissertation possible.

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Many individuals and organizations have contributed significantly to this dissertation. I would first like to thank the members of my committee for their help in bringing this research to fruition. Each made a unique and lasting contribution, not only to the dissertation but to me personally. Dr. Hendrick served as my chair. His valuable encouragement, guidance, and experience with JIT implementation in a defense industrial setting contributed to the heart and soul of this dissertation. Dr. Fearon is the busiest man I know, always too busy to just chat but never too busy to help solve a problem. He has served as my mentor throughout my entire doctoral program. Dr. Gritzmacher's probing questions forced me to critically evaluate and clarify my thought processes and objectives. Her positive encouragement and enthusiasm were contagious and greatly needed. Dr. Landeros helped me develop a theoretical perspective and introduced me to buyer-seller models that provided the theoretical underpinnings of the dissertation. Finally, I would like to recognize the contribution of Dr. Hutt, who directed me to streams of academic literature on defense contracting and transaction cost economics that formed the theoretical and empirical base for this dissertation. I would like to thank all of them for their time, patience, and kindness.

I would also like to acknowledge the support of the United States Air Force and the National Association of Purchasing Management (NAPM). Air Force sponsorship afforded me the opportunity to return to graduate school and permitted me to devote all my time to my doctoral studies and dissertation research. This research was funded by a grant from NAPM, which allowed me to expand the scope of the study to a greater number of defense contractors over a wider geographical area.

I owe a debt of gratitude to the defense contractors that granted me access to their facilities and to all the individuals that participated in the study. Unfortunately, they must remain anonymous. However, the research would have been impossible without their trust and participation. I hope the findings will be useful to them and partially repay them for their kindness and cooperation.

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TABLE OF CONTENTS

CHAPTER

LIST OF TABLES

Table

Table

LIST OF FIGURES

Figure

CHAPTER 1

INTRODUCTION

The purpose of this dissertation is to determine the impact government contracting policies, regulations, and practices have on a defense contractor's efforts to improve quality and productivity through the adoption of the Just-In-Time (JIT) philosophy into its production and purchasing operations. JIT is a continuous improvement process that encompasses the entire industrial system (raw material to finished product) and has as its ultimate goal the perfection of processes such that perfect products can be produced using the absolute minimum amount of time and resources. Some of the companies embracing the JIT philosophy in the United States are beginning to apply it to their defense operations. To the extent that JIT can be successfully applied in the highly structured, controlled, and compliance driven defense contracting environment, it has the potential to improve some of the productivity ills plaguing the defense industrial base to the benefit of the Department of Defense (DOD) and the defense contractor.

The Significance of JIT to the Defense Industrial Base

The lagging productivity growth rate in this country has become a national concern. The White House Conference on Productivity cited low productivity growth rates as having a highly detrimental effect on the economy. In fact, U.S. industry actually experienced a negative productivity growth rate in 1979, 1980, and 1982.[1] According to a Congressional study, such low productivity growth has had a particularly debilitating effect on the defense sector of the economy. That study produced the following findings (emphasis added):

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[1]White House Conference on Productivity, Productivity Growth A Better Life for America, Report to the President of the United States, April 1984, pp.11-12.

- the defense industrial base is unbalanced; while excess production capacity generally exists at the prime contractor level, there are **serious deficiencies at the subcontractor levels**;
- the industrial base is **not capable of surging production rates** in a timely fashion to meet the increased demands that could be brought on by a national emergency;
- **lead times** for military equipment have **increased significantly** during the past three years;
- **skilled manpower shortages** exist now and are projected to continue through the decade;
- the U.S. is becoming **increasingly dependent on foreign sources** for critical raw materials as well as for some specialized components needed in military equipment;
- **productivity growth rates** for the manufacturing sector of the U.S. economy are the lowest among all free world industrialized nations; The productivity growth rate of the **defense sector is lower than** the overall **manufacturing sector**;
- the means for **capital investment** in new technology, facilities and machinery have been **constrained** by inflation, unfavorable tax policies, and management priorities.[2]

The panel concluded the defense industrial base had deteriorated and was in danger of further deterioration.

The Department of Defense has attempted to reverse the trend by concentrating, for the most part, on technological solutions. Its Manufacturing Technology (ManTech) program sponsors research to develop new technology for defense industrial application while its Industrial Modernization Incentives Program (IMIP), provides seed money to help contractors upgrade their facilities with cost-reducing high technology.[3] DOD also reformulated its profit policy several times to motivate contractors to invest in cost-reducing equipment, an effort that has generally been regarded as unsuccessful.[4] Academic research has found

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[2]U.S., Congress, House, Committee on Armed Services Defense Industrial Base Panel, The Ailing Defense Industrial Base: Unready for Crisis, 96th Cong. 2nd Sess., December 31, 1980, p.11.

[3]See William H. Miller, "Pentagon Sows Seeds of Defense Productivity," Industry Week, July 13, 1981, pp. 48-53; Robert E. Harvey, "DOD's Not-So-Mean Fighting Machine," Iron Age, August 19, 1983, pp. 47-56.

[4]See Comptroller General, Recent Changes in the Defense Department's Profit Policy--Intended Results Not Achieved, GAO Report PSSAD-79-38, March 8, 1979; Letitia Kovich and Thomas McCann, "Evaluation of the Effectiveness of the Weighted Guidelines to Include Contractor's Investment in Cost Reducing Facilities Equipment," Fort Belvoir, VA, Defense Systems Management College, October 1984.

defense contractors are generally reluctant to make such investments.[5] JIT offers a less capital-intensive alternative to achieve productivity and quality improvement.

The JIT philosophy encourages actions that could help ameliorate many of the ills of the defense industrial base. JIT encourages supplier development, especially in terms of capacity, productivity, quality, and lead time improvements. It can increase a contractor's production flexibility and capacity to respond to increased demand (surge capability). It can dramatically reduce cycle times and overall lead time. JIT stimulates the development of worker skills and capabilities. It also encourages the development of domestic sources that can consistently provide exceptionally high quality parts and materials at competitive costs. JIT also stimulates capital investment, if required to support JIT efforts. Such activities, if conducted on a wide scale, would strengthen the defense industrial base and improve its capability to respond in a crisis.

JIT could also help defense contractors become more profitable and competitive. The competition for defense business has become increasingly intense in recent years. Since Congress passed the Competition in Contracting Act (CICA)[6] in 1984, which firmly institutionalized the use of competition within the Defense Department, DOD has greatly increased its use of competition in the awarding of contracts. During Fiscal Year 1986, the Navy used competition on 72.8 percent of its contracts (51.9 percent of its contract dollars), the Air Force competitively awarded 89.9 percent of its contracts (corresponding to 50.8 percent of its procurement dollars), and the Army did so for 81.8 percent of its contracts

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[5]Merton J. Peck and Frederic M. Scherer, The Weapons Acquisition Process: An Economic Analysis (Boston: Harvard University, 1962) pp. 164-170; J. Ronald Fox, Arming America: How the U.S. Buys Weapons (Boston: Harvard University, 1974) pp. 317-319; Jacques S. Gansler, The Defense Industry (Cambridge: The MIT Press, 1980) pp. 54-59.

[6]U.S. Public Law 98-369, July 18, 1984, Title VII, Competition in Contracting Act of 1984.

(representing 53.1 percent of its contract dollars).[7] These are up considerably from past years. This increased use of competition, combined with tighter defense budgets, has made competitive capability an increasingly important issue in the defense sector.[8] This corresponds somewhat to the highly competitive environment in the commercial world, where many Japanese and United States firms have used JIT to strengthen their competitive position.

Statement of the Problem

While JIT could be beneficial for defense contractors as well as for the defense industrial base, it is not clear whether the highly structured defense contracting environment is conducive to such efforts. The JIT literature generally suggests JIT can be applied to a broad range of U.S. industries and there have been a few references to JIT implementation by defense contractors.[9] The problem is that there are aspects of a contractor's operations that can be significantly impacted by the defense contracting process which is tightly controlled by the Federal Acquisition Regulation[10] (FAR) plus a host of other supplementary regulations and standards. Studies have found that despite attempts at improvement, defense contracting persists as a severely overregulated and inflexible process, often inhibiting the

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[7]U.S., Air Force, Office of the Competition Advocate General of the Air Force, Report to the Congress on Air Force Competition, 1986, pp. 2-3; U. S. Army, Office of the Competition Advocate General of the Army, Annual Report to Congress on Competition in Army Procurement, 1986, pp. 1-2; and U. S. Navy, Navy Procurement Competition: FY 1986 Report to Congress, 1986, pp. ii-iii.

[8]Eileen White, "Defense Contractors Slim Down to Survive Lean Times," Wall Street Journal, 30 September 1987, sec. 1, p. 6.

[9]See Richard J. Schonberger, "An Assessment of Just-In-Time Implementation," Readings in Zero Inventory, APICS 27th Annual International Conference, Las Vegas: n.p., 1984, p. 59; James F. Watson, Darrell Graddy, and Donald Longchamps, "A Vendor and Transportation Management Program to Support JIT," Proceedings, Council of Logistics Management Fall Meeting, October 5-8, 1986, Vol.II, Anaheim: n.p., 1986, pp. 316-319; Kiyoshi Suzaki, The New Manufacturing Challenge (New York: The Free Press, 1987) pp. 2, 65-67.

[10]U.S., Department of Defense, Federal Acquisition Regulation (Washington, D.C. Government Printing Office, 1984).

application of common sense to acquisition issues and leading to undesirable results.[11] Academic research has also confirmed defense contracting practices promote contractor inefficiencies.[12] According to Gansler,

> Essentially, there is a gap between what the structure, conduct, and performance of the defense-industry market require to achieve economic efficiency and strategic-production responsiveness and the actual laws, regulations, policies, and practices that are used to control this market. The government policy makers fail to recognize, or refuse to look at, this gross difference.[13]

This study examines the impact such controls have on a contractor's efforts to implement JIT into its production and purchasing operations. Two research questions are addressed.

Research Question 1

The amount of control or influence the government exerts over a contractor's operations varies by contractor and by contract. The range of possibilities consists of one polar extreme of fixed-price, competitively awarded contracts (where the government relies mostly on market mechanisms to control the relationship), to the other extreme of cost-reimbursement contracts (where contract administrative control mechanisms and incentives are used).[14] This represents a continuum ranging from minimal to maximal government involvement in, and control over, the internal operations of a defense contractor. This study is primarily concerned with contracts that lie toward the middle of the continuum, with moderate to heavy government control mechanisms, and the impact of that environment on JIT implementation. The first research question to be addressed is:

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[11]See President's Private Sector Survey on Cost Control, Report on Procurements/Contracts/Inventory Management, (Washington, D.C.: Government Printing Office, 1983), pp. i-ii; and President's Blue Ribbon Commission on Defense Management, A Quest for Excellence: Final Report to the President, (Washington D.C.: Government Printing Office, 1986), pp. xxi-xxiv, 44-48.

[12]See Peck and Scherer, pp. 586-595; Frederic M. Scherer, The Weapons Acquisition Process: Economic Incentives (Boston: Harvard University, 1964) pp. 1-12, 372-399; Fox, pp. 384-428, 449-450; and Gansler, pp. 72-96, 219-228.

[13]Gansler, p. 2.

[14]Peck and Scherer, pp. 61-63; Scherer, pp. 132-137.

> What characteristics of the contractual relationship significantly explain variances in 1) the impact of contracting policies, requirements, and practices on JIT production and purchasing efforts and 2) the extent of JIT production and purchasing activities undertaken?

Research Question 2

The first research question focuses on how conducive the defense contracting environment is to JIT in general. The second research question deals with the specific contracting policies and practices, which could have positive, negative, or neutral impacts on JIT activities. Gansler suggests contracting regulations tend to have negative overall impacts.

> These regulations provide detailed information on exactly how defense business is to be conducted, and are the reason why firms doing business with the DoD have special accounting systems, special quality control procedures, special drawings, special soldering techniques, and so on.
>
> . . . When a specific example of abuse is found, another regulation is added--to be universally applied. For the single case involved, the corrective action may or may not work; the cumulative impact of these actions is rarely considered, nor is their interrelation. Thus, the specific problem in the individual firm may be corrected, but the impact of the regulation on the overall industry is likely to be negative and expensive.[15]

Such regulations serve as parameters to the contractor. However, the JIT philosophy does not permit the meek acceptance of such parameters.[16] Contractors adopting JIT should squarely face the contracting parameters that conflict with JIT. Thus, the second research question is:

> What linkages exist between defense contracting policies, requirements, and practices and JIT production and purchasing activities?

Overview

This first chapter has introduced the research problem and defined the questions that served as the objectives for this research. It also provides brief chapter summaries to serve as an overview of the research conducted to answer the research questions.

Chapter 2 presents a literature review covering three main areas. First, it provides a review of the JIT literature to determine what is known, or at least can be deduced, about

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[15]Gansler, p. 73.

[16]Robert W. Hall, Zero Inventories (Homewood, Ill.: Dow Jones-Irwin, 1983) pp. 2-3.

the application of JIT by U.S. industries, in general, and by defense industries, in specific. Various definitions and models of JIT are evaluated to provide a framework for discussion and analysis. Conceptual and empirical studies concerning JIT implementation problems and benefits are evaluated as to their applicability to defense contractors. The Heard model of short cycle manufacturing is introduced which was used as the framework for selecting and defining JIT variables.

The second portion of the literature review examines the limited amount of research that has been conducted in the area of defense contracting. The research suggests companies wishing to do business with the government generally face a more powerful customer, greater uncertainty, higher levels of customer influence and control over their internal operations, and a more structured and complicated contracting relationship than they would encounter in the commercial sector of the economy. The actual level of government control varies depending on the particular contract and contractor. This literature provided the basis for selecting predictor variables used to model the defense contracting environment.

The last portion of the literature review focuses on buyer-seller relationships based on transaction cost economics and general systems theory. Transaction cost economics provides a theoretical framework for defining the contractual arrangement used to govern the buyer-seller relationship. Depending on its characteristics, the transaction can most efficiently be governed by market forces (in which case the parties maintain a high degree of independence) or by varying levels of contract mechanisms and arrangements (in which case mutual dependencies are created) or by internal control mechanisms (in which case vertical integration occurs). Systems theory focuses on whether two systems are joined loosely (and are therefore independent) or whether the systems are more tightly joined (and are interdependent) or in the extreme are fully joined (and are totally interdependent). The two frameworks are interrelated and provided the theoretical underpinnings for modeling the defense contracting environment.

Chapter 3 defines a conceptual model of JIT implementation in a defense contracting environment, providing the framework for the study's variable selection. It uses theoretical

constructs drawn from transaction cost economics and systems theory and observed variables drawn from the defense contracting literature to model contract arrangements in terms of the extent of government control that is exerted over the contractor. The defense contracting literature combined with the results of discussions with defense contractors, consultants, and defense contracting personnel were used to identify the contracting policies, practices, and requirements that might impact JIT. A JIT Model identified from the literature review served as a framework to describe JIT activities.

Chapter 4 describes the research methodology. It describes the field study used to answer the research questions. The sample selection process is described, as are the resulting sample of five JIT users in the defense electronics who participated in the study. The data gathering methods are introduced, specifically the development and pretest of the structured interview documents, the interview protocol used, and the final instruments used in the conduct of the actual research. Chapter 4 also further defines the research questions and identifies the methodology that will be used to answer them. Four hypotheses and sixteen sub-hypotheses are developed for research question one. These concern expected relationships between the characteristics of the contracting environment and the impact of government control mechanisms on JIT production and purchasing efforts. For the second research question, which is entirely exploratory in nature, general expectations are developed concerning three sub-research questions. The chapter concludes with a description of the statistical methodology used to test the hypotheses and to answer the research questions. The multiple linear regression techniques and multivariate principal component analyses used to test the hypotheses for the first research question are explained. Finally, the parametric/nonparametric tests and the descriptive statistical methods used to answer the second research question are described.

Chapter 5 presents the results and findings of the research. It describes the results of the multiple linear regressions and their impact on the hypotheses developed to answer the first research question. This identifies the characteristics of the contract relationship that have the greatest impact on JIT production and purchasing, in terms of the overall impact of

government controls and the extent of implementation. Next, production and purchasing responses are analyzed descriptively and statistically to determine if the overall impact of government controls on JIT purchasing is greater than those same controls on JIT production. Finally, purchasing and production responses are analyzed and discussed to identify the impact of specific contracting controls on individual JIT activities.

Chapter 6 provides an overall summary of the findings and addresses the implications raised by the research results. It summarizes the findings associated with each research questions and discusses their implications. It also addresses the managerial and theoretical implications of the study. Finally, it describes the study's limitations and provides suggestions for future research.

CHAPTER 2

LITERATURE REVIEW

Companies attempting to apply JIT to their defense operations face many of the same challenges that commercial and non-defense industrial firms encounter plus the requirement of satisfying the defense contracting policies and requirements applicable to their contracts. This chapter presents a literature review to determine what is known about the application of JIT principles in a defense contracting environment. The JIT literature is examined to define and model the application of JIT to industries in the United States and to identify potential problems and benefits, especially as they apply to defense industries. The next section examines the defense contracting literature to determine the unique characteristics of that environment and the impact it has on defense contractors. The last section reviews buyer-seller models based on general systems theory and transaction cost economics. This provides the theoretical basis for modeling the defense contracting environment in terms of the degree of control the government exerts over a contractor's operations and the effect such controls have on the contractor's JIT production and purchasing efforts.

JIT Literature

The JIT literature consists chiefly of conceptual and descriptive treatises intermixed with examples and case studies. The results of empirical research is just starting to emerge. The literature is replete with commercial JIT applications but is almost devoid of defense industry examples, even though many of the JIT companies cited in the literature are large defense contractors as well. The JIT literature does provide a useful framework for analysis in terms of JIT models, concepts, and principles as applied in industrial settings in the United States.

JIT Conceptual Models

Part of the difficulty in conducting JIT research is the lack of a universally accepted and understood definition or model of JIT. Terminology varies considerably by author and by company, each using a particular conceptualization or operationalization of JIT. The JIT elements listed in Table 1 and Table 2 respectively list JIT production and purchasing elements described by various authors. These lists are by no means comprehensive and there is considerable subjectivity involved in comparing JIT descriptions by different authors. However, the lists do suggest several things. First, there appears to be general agreement on some elements, which could be considered core JIT production and purchasing elements. There is also a greater consensus on JIT purchasing activities than production techniques, perhaps because purchasing activities, as Shealy has shown, are quite similar across industries.[1] Production systems can vary substantially and JIT techniques useful in one situation may not be as applicable in another. Thus, defining JIT solely as a set of techniques is not very practical, at least where JIT production is concerned, unless one is describing a particular JIT application. Moreover, such lists fail to catch the spirit of JIT and can lead to a superficial view of it. According to Hall, JIT cannot be confined to a set of techniques but must be seen as a systems approach to improving operations to the highest degree possible.[2] Shingo suggested that while one must understand JIT techniques, one must also know why they are used and understand the relationships between them.[3] Therefore, a useful model must capture the philosophy behind JIT and the relationship between the techniques.

Some attempts to describe and model JIT did so in terms of Toyota's experience in developing JIT concepts. Sugimori et al. described the Toyota Production System (the forerunner of what has come to be known as Just-In-Time production in the United States)

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[1]Robert Shealy, "The Purchasing Job in Different Types of Businesses," Journal of Purchasing and Material Management 21 (Winter 1985) 17-20.

[2]Robert W. Hall, Zero Inventories (Homewood, Ill.: Dow Jones-Irwin, 1983), pp. 10-11.

[3]Shigeo Shingo, Study of TOYOTA Production System from Industrial Engineering Viewpoint (Tokyo: Japan Management Association, 1981) pp. 332-333.

Table 1

A Comparison of JIT Elements

JIT Elements	Shingo	Monden	Hall	AIAG
"Pull" Production Control System, i.e. Kanban	X	X	X	X
Production Smoothing/Leveling	X	X	X	X
Setup Time Reduction	X	X	X	X
Small Lot Size/One Piece Production & Conveyance	X	X	X	X
Machine Layout/Group Technology	X	X	X	X
Inventory Minimization	X	X	X	X
Visual Control System	X	X	X	X
Total Quality Control	X	X	X	X
JIT Production/± Zero to Schedule	X	X	X	X
Small Group Improvement Activity/ Worker Participation		X	X	X
Total Preventive Maintenance	X		X	X
Flexible Work Force/Multi-Machine Handling	X	X		X
Automation	X		X	X
JIT Supplier Network		X	X	X
Standardized/Synchronized Operators-Line Balancing	X	X	X	
Functional Management/Management by Consensus		X		X
Company Labor Unions				X
Product Design/Value Engineering	X		X	
Long-term Employee Relationships				X
Focused Factory				X

SOURCES: Shigeo Shingo, Study of TOYOTA Production System from Industrial Engineering Viewpoint (Tokyo: Japan Management Association, 1981); Yasuhiro Monden, Toyota Production System (Atlanta: Industrial Engineering and Management Press, 1983); Robert W. Hall, Zero Inventories (Homewood,Ill: Dow Jones-Irwin, 1983); Automotive Industry Action Group, The Japanese Approach to Productivity, Video Tape Series, 1983.

Table 2

JIT Purchasing Characteristics

Characteristic	Schonberger	Giunipero	Hay
Supplier Total Quality Control/SPC	X	X	X
Just-In-Time Deliveries	X	X	X
Long-term Contracts/Supplier Partnerships	X	X	X
Geographical Concentration of Suppliers	X	X	X
Fewer Suppliers/Increased Single Sourcing	X	X	X
Supplier Incorporation of JIT/Efficient Operations	X	X	X
Reliable, Controlled, Repetitive Delivery/Transportation Patterns	X	X	X
Minimize Receiving/Material Handling, i.e. Standard, Reusable Containers, Labels, etc.	X	X	X
Rapid, Close, Continuous Communication System	X	X	
Supplier Input into Design/VA	X	X	
Mixed, Consolidated Shipments/ Sequential Loading	X	X	X
Only Essential Specifications in Contract	X	X	
Minimize Administrative/Paperwork Requirements	X	X	X

SOURCES: Richard J.Schonberger, Japanese Manufacturing Techniques (New York: Macmillan Free Press, 1982), Ch. 7; Larry C. Giunipero, "JIT Purchasing," Guide to Purchasing (New Jersey: National Association of Purchasing Management, 1986); Edward J. Hay, "Will the Real Just-In-Time Purchasing Please Stand Up," Readings in Zero Inventories, APICS 27th Annual International Conference, (Las Vegas, n.p., 1984) pp. 90-92.

in terms of two underlying concepts: 1) a total and continuing commitment to reduce costs by eliminating all waste in a system, and 2) respect for humanity, to safeguard human resources and fully utilize their capabilities and creativity to discover and eliminate waste.[4] Monden modeled the contributions and interrelationships of JIT elements to the objectives of eliminating waste, achieving total quality control, and developing respect for humanity.[5] Shingo modeled JIT in terms of how the various techniques work together to eliminate the wastes of 1) over-production, 2) waiting, 3) transportation, 4) processing itself, 5) stocks, 6) motion, and 7) the making of defective products.[6] Shingo's model is especially useful for the detailed relationships he described and his definition of seven wastes.

Other authors drew upon the eclectic experiences of Japanese, and to a limited degree, United States companies. Hall defined four wastes (time, energy, material, error) and described JIT as a systems approach but did not model the system.[7] Suzaki used Shingo's seven wastes and modeled the relationship of JIT elements to waste elimination.[8] Chapman considered three forms of waste reduction efforts: 1) direct waste reduction, 2) uncertainty reduction and the elimination of slack resources which serve as buffers, and 3) determination of the most cost effective method of dealing with the remaining uncertainty.[9] Such models are useful in focusing attention on why JIT techniques are employed and how they fit into the overall JIT philosophy. They are more generalizable than focusing solely on JIT

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[4]Y. Sugimori et al., "Toyota Production System and Kanban System: Materialization of Just-In-Time and Respect-for-Human System," International Journal of Production Research 15 (1977): 554-559.

[5]Yasuhiro Monden, Toyota Production system: Practical Approach to Production Management (Atlanta: Industrial Engineering and Management Press, 1983), p. 3.

[6]Shingo, p. 287.

[7]Hall, pp. 4-5, 9-10.

[8]Kiyoshi Suzaki, The New Manufacturing Challenge: Techniques for Continuous Improvement (New York: The Free Press, 1987) pp. 7-18, 234.

[9]Stephen N. Chapman, "A Descriptive Analysis of the Subcontractor/Supplier Linkages Within a Just-In-Time Environment in the U.S. Automotive Industry" (Ph.D. dissertation, Michigan State University, 1986).

techniques.

Heard developed a simple, yet useful, model (Figure 1) that focuses on five necessary conditions to attain short-cycle manufacturing (his name for JIT). Structured Flow Paths refers to the layout of plant equipment to minimize material movement. People Leverage calls for a work climate that fully develops and utilizes the potential, capability, knowledge, skills and creativity of its employees. Continuous Flows refers to the velocity and consistency of the flow of material which is achieved by eliminating all causes of flow disruption. A Linear Operation is one in which the flow of material, from process to process, is in the smallest lot sizes possible and is synchronized into stable and repetitive patterns. Dependable Supply and Demand seeks to reduce or eliminate variability and uncertainty emanating from customers and suppliers. These five conditions work together in a synergistic way to work perfect the flow of material throughout the entire system.[10]

Heard's model is useful because it is conceptually simple and generalizable. Each required condition has a host of supporting tools available so it is not technique specific. It is also structured enough to provide a useful framework for comparing JIT activities. The Heard model does not include management commitment as an element of the model although the requirement for management policy changes is recognized as an essential ingredient for successful implementation.[11] Implementation issues are discussed next.

Implementation Issues

One important implementation issue concerns the applicability of JIT to various types and sizes of industries. Schonberger suggested labor intensive, repetitive manufacturing industries with large volumes most easily absorb JIT, with process industries close behind. He also indicated low volume, high variety job shop producers face the most complex task.

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[10]Ed L. Heard, " The Direct Route to JIT", Proceedings, APICS International Conference (Falls Church, Virginia: n.p., 1985).

[11]Ed L. Heard and Julie A. Heard, "Management Policy Changes--Musts for JIT," Proceedings, APICS International Conference (Falls Church, Virginia: n.p., 1986).

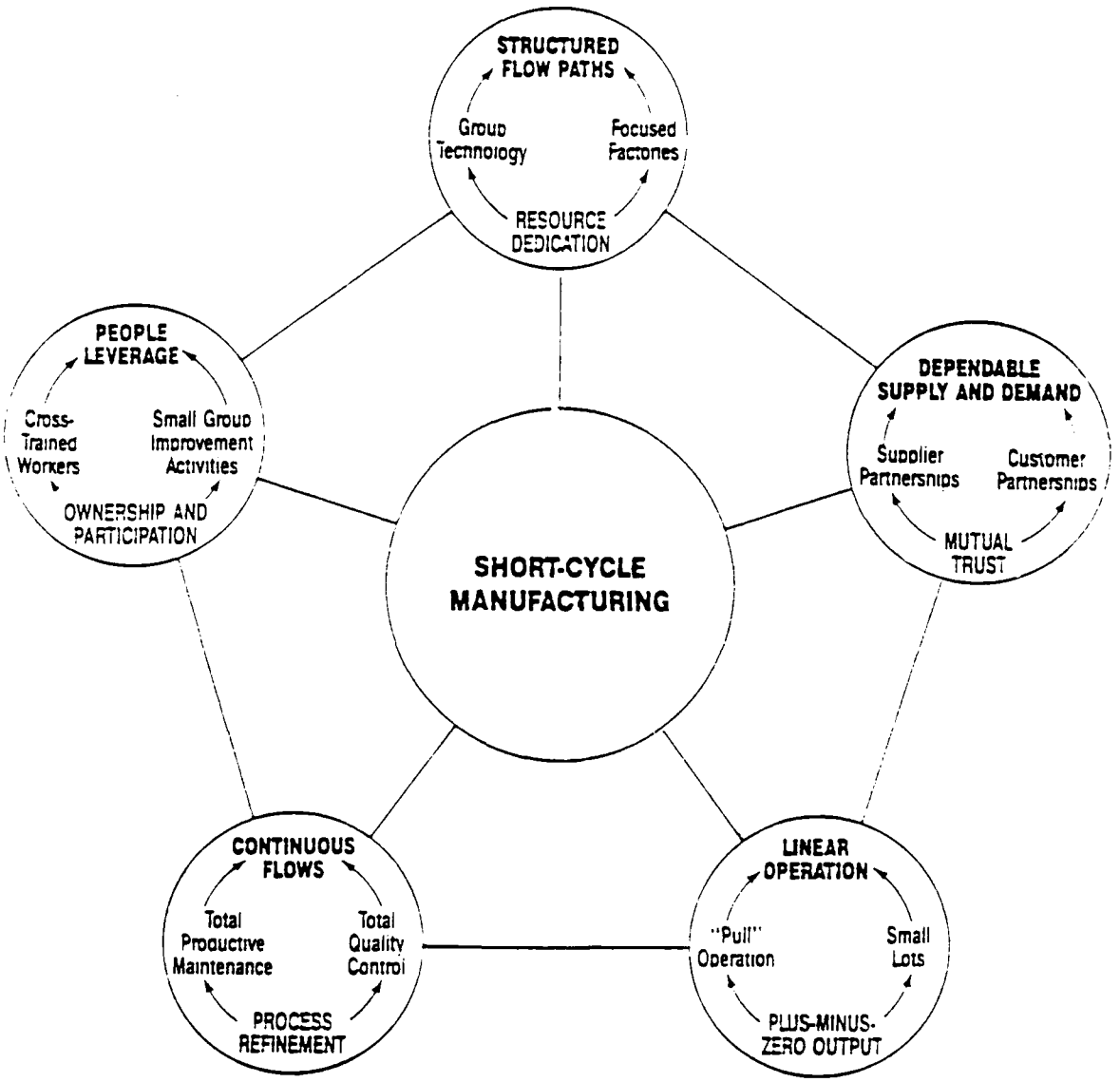

Figure 1. Heard Model of Short Cycle Manufacturing

He cited the experiences of large companies experiencing JIT success even in a job shop environment.[12] Youngkin addressed the issue of JIT implementation in a job shop manufacturing environment, suggesting that job shops face more difficult implementation challenges than repetitive manufacturers but also have the potential for achieving much greater benefits. He demonstrated how various JIT elements apply in the job shop environment.[13] Finch and Cox addressed JIT implementation by the small manufacturer and found JIT benefits could be achieved but were limited because some aspects of JIT are difficult or infeasible for small manufacturers.[14] These observations are based on case studies or the authors' experience. Celley et al., conducted an empirical study of JIT implementation in the automotive industry and found neither company size nor process type influenced a company's decision to implement JIT.[15] Since their study focused only on automotive companies, their findings may not be generalizable to other industries. Taken as a whole, the literature suggests a wide variety of manufacturing environments can achieve the benefits of JIT.

Empirical evidence is beginning to surface that suggests companies can benefit greatly from JIT. Ritzman et al. verified through simulation that many of the elements of Just-In-Time can dramatically improve manufacturing performance in the United States industrial setting.[16] A subsequent simulation by Krajewski et al. covering a wide range of plant

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[12]Richard J. Schonberger, "An Assessment of Just-In-Time Implementation," Readings in Zero Inventory, APICS 27th Annual International Conference (Las Vegas: n.p., 1984) pp.58-59.

[13]Jack G. Youngkin, "Implementing Zero Inventory Production in a Job Shop Manufacturing Environment," Readings in Zero Inventory, APICS 27th Annual International Conference, Las Vegas: n.p., 1984, pp. 63-66.

[14]Byron J. Finch and James F. Cox, "An Examination of Just-In-Time Management for the Small Manufacturer: With an Illustration," International Journal of Production Research 24 (1986): 329-342.

[15]Albert F. Celley et al., "Implementation of JIT in the United States," Journal of Purchasing and Materials Management 22 (Winter 1986): 14.

[16]Larry P. Ritzman, Barry E. King, and Lee J. Krajewski, "Manufacturing Performance--Pulling the Right Levers," Harvard Business Review 84 (March-April 1984) pp. 143-152.

environments found critical factors for increasing manufacturing performance were improving lot sizes, setup times, yield losses, work force flexibility, product customization, and product structure. JIT activities to improve these areas led to improved operations but Kanban was not found to be crucial in and of itself.[17] A 1985 survey found that companies using JIT had realized reductions in inventory, lead times, manufacturing costs, and paperwork and had achieved improvements in quality.[18] These results are based on descriptive statistics only and no information is provided concerning the makeup of the population nor the methodology employed. O'Neal conducted an empirical study of JIT purchasing in the automotive industry and generally confirmed that JIT purchasing activities result in increased productivity and quality, although the effect on supplier finished inventories was mixed.[19] Research by Ansari and Modarress also suggested JIT purchasing can yield substantial improvements in inventory turnover, delivery promises met, delivery lead time, scrap costs, productivity and quality.[20] Their study included a cross-section of U.S. industries but only descriptive statistics are provided and they are based on a small sample size. The limited research reported to date has tended to confirm the benefits commonly attributed to JIT.

An implementation issue related to benefits is the measurement of JIT results and performance. Hall maintained that inventory level is an important measure of overall production efficiency. He also suggested six performance measurement areas, 1) improvement trends (including cost, productivity, and projects), 2) quality trends, 3) schedule

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[17]Lee J. Krajewski et al., "Kanban, MRP, and Shaping the Manufacturing Environment," Management Science 33 (January 1987): 56-57.

[18]"American Industry Goes Ape Over Just-In-Time Strategy," Purchasing, 12 September 1985, p.21.

[19]Charles R. O'Neal, "The Buyer-Seller Linkage in a Just-In-Time Environment," Journal of Purchasing and Material Management 23 (Spring 1987): 9-12.

[20]A. Ansari and Batoul Modarress, "The Potential Benefits of Just-In-Time Purchasing for U.S. Manufacturing," Production and Inventory Management 28 (2nd Quarter 1987): 30-35.

attainment, 4) inventory trends, 5) budget, and 6) work force development.[21] Suzaki found Work-In-Process turnover to be a consistent indicator of productivity improvement for the one western and three Japanese auto companies studied.[22] Hendrick suggested baseline measures must be established as an integral part of JIT implementation. He recommended inventory turnover or its inverse, cycle time, as a global measure of JIT success and decomposed turnover and cycle times as measures for specific areas.[23] Appropriate measurement tools are necessary for identifying problem areas, assessing the progress of JIT implementation, and determining the benefits achieved.

Another significant issue is the proper sequence of JIT implementation. Even though JIT appears to be widely applicable and beneficial to U.S. companies, it must be properly implemented to achieve its full benefits. Shingo maintained improper implementation can lead to adverse effects and proposed a sequence based upon the experience of Toyota.[24] Hall also suggested a detailed implementation guide.[25] Both suggested the organization must be thoroughly prepared so everyone, especially top management, has a complete understanding of and commitment to JIT principles. Next, they suggested JIT should be implemented internally, before involving suppliers, although the exact sequence they recommend differs somewhat. Shingo stresses the use of setup reduction and layout changes early in his sequence with production leveling occurring toward the end. Hall encourages simultaneous efforts to level the production schedule and reduce setups to be followed by layout changes. Hall also incorporates organizational changes, such as revision of performance measures and product realignment. Both include process improvement as an early activity and converting to a pull

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[21]Hall, pp. 11, 249-256.

[22] Kiyoshi Suzaki, "Work-In-Process Management: An Illustrated Guide to Productivity Improvement," Production and Inventory Management 26 (Third Quarter, 1985): 101-110.

[23]Thomas E. Hendrick, "The Pre-JIT/TQC Audit: First Step of the Journey," Production and Inventory Management 28 (Second Quarter, 1987): 134-135.

[24]Shingo, pp.332-333.

[25]Hall, pp.257-294.

system and supplier involvement as latter activities.[26] Hall recognized his implementation scenario is based primarily upon the experience of Japanese companies and that problems likely to beset companies in the United States must be extrapolated.[27] Subsequent research has highlighted some of those problems.

Empirical studies of U.S. firms implementing JIT have identified some of the major implementation problems. Celley et al. analyzed 131 survey responses (Automotive Industry Action Group firms) concerning JIT implementation. Their findings concerning process type and size were reported earlier. They identified the following implementation problems experienced by the automotive industry (in descending order):

Customer Schedule Changes
Poor Supplier Quality
Poor Production Quality (Internal)
Inability to Change Paperwork Systems
Shortage of Critical Parts
Supplier Inability to Deliver JIT
Lack of Employee Commitment
Inability to Reduce Setup Time
Inadequate Equipment & Tooling
Surplus of Non-Critical Parts
Lack of Top Management Commitment
Labor Contract Problems[28]

This points to potential problem areas defense contractors are likely to face. With the exception of setup time reduction and labor contract problems, these problems could be exacerbated by the defense contracting environment.

There are also indications that JIT companies are having considerable difficulty developing cooperative, long-term supplier relationships. Lorincz reported the results of a survey conducted by the National Screw Machine Products Association on its 500 member companies (response rate not provided), which concluded the following:

1. There is no uniform, consistent approach to JIT
2. Original Equipment Manufacturers are not strongly supporting JIT through the use of long-term contracts

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[26]See Shingo, p. 332; and Hall, pp. 263.

[27]Hall, p.258.

[28]Celley et al., p. 14.

3. There is little infrastructure and incentive to support JIT
4. Complying with JIT initially increases costs and forces suppliers into "difficult, long-range, high-impact decisions"[29]

Ansari and Modarress identified the following significant problems involved with the implementation of JIT purchasing by a cross-section of U.S. companies (listed in order of significance):

1. Lack of support from suppliers
2. Lack of top management support
3. Low product quality
4. Lack of employee readiness and support
5. Lack of support from carrier companies
6. Lack of engineering support
7. Lack of communication[30]

Their study is based on a survey of unspecified size and on-site research at four major companies in the United States. Chapman conducted a field study of JIT supplier relationships in the automotive sector. It included one major automobile division, 21 suppliers, and 89 products. He found that suppliers who do not incorporate JIT into their own production process respond to the customer's JIT demands by continually expediting and/or holding extra inventories, making JIT less cost effective.[31] These studies suggest companies are having difficulty developing long-term JIT supplier relationships and encouraging suppliers to incorporate the JIT philosophy in their own operations. Forming JIT partnerships with suppliers appears to be a formidable task for United States companies. This may be especially so for companies operating in the defense contracting environment since their purchasing activities tend to be highly regulated.

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[29]James A. Lorincz, "Suppliers Question Approaches to JIT," Purchasing World, March 1985, p. 74.

[30]A. Ansari and Batoul Modarress, "Just-In-Time Purchasing: Problems and Solutions," Journal of Purchasing and Material Management 22 (Summer 1986): 12.

[31]Chapman, pp. 112-114.

JIT and Defense Contracting

There is a paucity of information in the JIT literature focusing directly on JIT implementation by defense industries. However, the references that have appeared are quite encouraging.

Templin and Hendrick analyzed how JIT implementation might be affected by the defense contracting environment based on a review of contracting regulations and interviews with defense contractors and government contracting personnel.[32] Their assessment used Heard's five necessary conditions as a basis for analysis.

They suggested government regulations should have only a minor impact on most JIT production efforts, especially in terms of achieving structured flow paths, people leverage, and a linear operation. However, they warned that structured flow paths can be impacted by government owned facilities/equipment and government controls over process specifications, tests, and quality inspections. They also suggested people leverage activities (especially developing a flexible work force) could be impacted by government quality practices, Cost Accounting Standards (CAS), and extensive reporting requirements. They further determined that contractors should enjoy almost complete freedom to conduct activities associated with a linear operation, especially since DOD demand (in the short run) is stable and supportive of such activities.[33]

Their analysis suggested contractors' efforts to achieve continuous, uninterrupted flows of material could face a more restrictive environment, depending on equipment ownership, product and process specification control, and the required quality inspection requirements. They identified government-owned equipment and government controls over process and product design specifications as potential restrictions for improving equipment, processes, and product design. They noted that DOD encourages value engineering (FAR 48) but the process for obtaining approval for engineering changes can be complicated and

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[32]Carl R. Templin and Thomas E. Hendrick, "Is the Defense Contracting Environment Conducive to JIT/TQC?" Logistics Spectrum 22 (Fall 1988) 5-13.

[33]Ibid, pp. 8-11.

lengthy. They also determined that while many TQC activities are in harmony with government quality requirements (such as statistical process control, efforts to increase worker consciousness toward quality improvement, and use of foolproof mechanisms to prevent errors), higher level government quality standards stress separate quality inspections (by contractor and government quality inspectors) and rely on batch-oriented sampling and inspection methods, which are contrary to the JIT/TQC philosophy.[34]

Of all the required conditions for JIT, dependable supply and demand were cited by Templin and Hendrick as the most difficult for a defense contractor to achieve because government contracting regulations tend to be at their highest when it comes to the interface between the government and the contractor and between the contractor and its suppliers. They pointed to the negotiation process, government audits, profit policy, the Truth in Negotiation Act (Public Law 887-653), and erratic long-term demand as not conducive to long-term relationships based on mutual trust. They further determined that efforts to develop long-term, close relationships with JIT suppliers could be complicated by Mil-spec certified supplier requirements, government specified sources, government subcontracting policies (favoring competition and discouraging single sourcing), socioeconomic policy (FAR 52), audits, and Contractor Purchasing System Reviews (FAR 44.3).[35]

Some companies operating in a government contracting environment have been cited in the literature for their JIT efforts. Blood described the application of JIT principals by Honeywell, Inc. to control inventory in a defense "Make-to-Order-Job Shop" which resulted in inventory reductions to about one third of the industry average.[36] Two defense contractors (IBM and Texas Instruments) appeared on Schonberger's "Honor Roll" for successful JIT implementation. An IBM plant was credited with reducing flow distance from 31,000 to 275 feet, cutting work-in-process (WIP) inventories by 70 percent, and shortening

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[34]Ibid, pp. 9-10.

[35]Ibid, pp. 11-12.

[36]Barry E. Blood, "Using Zero Inventory Ideals in a Government Contract," in APICS Aerospace and Defense Seminar Proceedings (Las Vegas, Nevada: n.p., 1985), pp. 109-113.

lead times by 50 percent. A Texas Instruments facility reduced metal fabrication WIP from 18,000 to less than 1000 pieces, cut production lead time from 14 days down to 2 days, and decreased scrap and rework "four- to fivefold."[37] Mueller provides an extensive review of Hughes' application of JIT principles to its production facilities. Its Radar Systems Group reduced cycle time from 35 days to 10 days and decreased WIP from 6,500 units to 1,200 units for multilayer printed wiring boards. Its Ground Systems Group achieved cycle time reductions from 55 to 20 days and cut WIP from 24,000 to 4000 boards. It has achieved similar results in other areas as well.[38] Douglas Aircraft and Martin Marietta Aerospace are cited for their efforts at achieving JIT for inbound materials supporting defense production efforts. Martin Marietta reduced discrepant incoming material, reduced receiving time form 90 days to 17 days, and decreased total transportation costs even though items shipped increased by nearly 50 percent.[39] Sandia National Laboratories instituted a successful JIT purchasing system that conformed to government contracting requirements. As a result, it eliminated an entire warehouse with its inventory, reduced paperwork, improved service levels and quality, and lowered overall prices associated with its maintenance, repair, and operations (MRO) items.[40] While the list is short, it is encouraging that some government contractors are having successful JIT experiences.

While there are aspects of the defense contracting environment that could restrict a contractor's JIT efforts, they should not be overwhelming, impassable obstacles. Even in the

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[37]Richard J. Schonberger, World Class Manufacturing: The Lessons of Simplicity Applied (New York: The Free Press, 1986) pp. 231, 235.

[38]William M. Mueller, "Cycle Time Management and Just-In-Time at Hughes," Unpublished paper presented at an internal conference at Hughes Aircraft Company, Los Angeles, March 19, 1987.

[39]See Francis J. Quinn, "How Airfreight Fits into the Just-In-Time Picture," Traffic Management, June 1985, pp. 79-81; James F. Watson, Darrell Graddy, and Donald Longchamps, "A Vendor and Transportation Management Program to Support JIT," in Council of Logistics Management, Annual Conference Proceedings Vol. II (Anaheim, Calif.: n.p., 1986), pp. 316-320.

[40]James P. Morgan "Who Says 'Just-In-Time' buying is only for Production?" Purchasing, February 13, 1986, pp. 66-71.

most restrictive contracting environment, contractors should still be somewhat free to develop structured flow paths, people leverage, and linear operations, although government contracting practices are bound to have some effect. Efforts to achieve continuous flows will likely be impacted by higher level quality requirements and subcontracting restrictions are likely to inhibit JIT purchasing activities. As suggested earlier, quality and supplier problems appear to plague JIT implementation in general. Increased government controls in these areas could have a significant impact on a contractor's JIT efforts. The extent to which defense contracting practices affect a contractor's JIT efforts is likely to depend on the specific buyer-seller relationship between the government and the defense contractor. The defense contracting literature therefore must be considered to determine the types of buyer-seller relationships and levels of government control that contractors face.

The Defense Contracting Literature

The buyer-seller relationship between the DOD and the defense contractor can vary substantially in terms of the amount of contracting regulation and government control the contractor experiences. There has been only a limited amount of academic research and analysis in this area, mostly centered on the acquisition of major weapon systems. However, the studies that have been undertaken have been quite exhaustive and provide valuable insight into the unique defense contracting buyer-seller relationship.

The seminal work in the area is by Peck and Scherer who, based on extensive case studies, conducted an analysis of the overall economic structure of the weapons acquisition process. While the details of their study are considerably out of date, their general findings are still very much applicable. They identified a shift from the use of government-owned arsenals to increased reliance on the private sector for weapons production. However, they concluded the nonmarket nature of defense contracting resulted in the "arsenalizing or socialization of private firms" due to a unique set of uncertainties and risks that differentiate the weapons acquisition process from any other economic activity.[41] This uncertainty arose

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[41]Peck and Scherer, pp. 17, 97, 582-583.

from the highly advanced, technical nature of military weapons as well as external uncertainties due to changes in military strategies and threats, the power of the government as a sole buyer, political policy shifts, and appropriation uncertainties.[42] They also determined a true market system did not operate in the defense contracting arena because prices were largely based on incurred or anticipated costs, not competitive prices; the buyer exercised control over the sellers by audits and other activities which involve the government in the external management of its contractors; and the government specified the weapons to be created.[43] Concerning the impact of this nonmarket, contracting system on the defense contractor, Peck and Scherer suggested that the contractor

> deals with a bureaucratic maze for a customer. Some of the occupants of this maze may be less than fully qualified for their demanding jobs. Second, the nonmarket character of weapons acquisition brings the customer into his internal operations in such a way that restricts his freedom to manage his own business.[44]

Their study focused on the acquisition of major weapon systems, the most complicated, uncertain, and highly controlled defense contracting environment.

In addition to describing the characteristics of the contracting process, Peck and Scherer classified various types of contractors and contracts. They defined weapon systems firms as delivering complete weapon systems to the government under a prime contract (a contract directly with the government). Subsystem firms were defined as selling major subsystems either under a prime contract or under a subcontract to a prime contractor. The remaining contractors were classified as parts firms or materials makers, selling component parts or materials either directly to the government or to prime contractors, usually under purchase order arrangements.[45] They also identified a continuum of contract possibilities which at one extreme uses competition to award fixed-price contracts for well-specified

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[42]Peck and Scherer, pp. 17, 25-52.

[43]Ibid, pp.56-60, 582.

[44]Ibid, p. 586.

[45]Ibid, pp. 114-115.

products (akin to a market system) and at the other extreme, uses negotiation to award cost plus fixed-fee contracts for highly uncertain tasks, substituting administrative control mechanisms and armies of auditors, plant representatives, etc. for market mechanisms. Weapon system firms fell toward the latter end of the spectrum.[46] Subsequent research has drawn heavily from these contract and contractor classifications. Their analysis suggests the actual level of government control in the contracting relationship depends on the role of the defense contractor, the type of product, and the type of contract.

Building on the work of Peck and Scherer, and using the same data, Scherer researched the impact of competitive and contractual incentives on a contractor's performance. Scherer defined the problem as follows:

> Program size and uncertainty interact in weapons acquisition to compel the shifting of financial risks from contractors to the government through such devices as the cost reimbursement contract.
>
> An additional complication is the fact that once a weapons program is under way, the contractor accumulated specialized experience and physical assets to a degree severely restricting the government's ability to bring in an alternate contractor. Buyer and seller are locked together in a relationship analogous to bilateral monopoly for the life of the program, *and they must* deal with each other on a bargaining basis.[47]

Scherer determined that, because of this nonmarket relationship, the government structured its relations with contractors through controls over the contractors' operations or through incentive mechanisms.[48] Scherer defined a variety of fixed-price and cost-reimbursable contracts with incentive and other mechanisms used to shift risk between the government and the contractor, using the same contracting continuum developed in Peck and Scherer's earlier work. He focused on the cost sharing arrangements negotiated such that the government and the contractor share deviations from target costs by an agreed upon percentage. He found the single most important factor influencing the choice of contract type was the degree

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[46]Peck and Scherer, pp. 57-62.

[47]Ibid, pp. 1-2.

[48]Ibid, p. 2.

of uncertainty associated with cost estimates.[49]

Scherer conducted a detailed analysis of the effect of such incentive mechanisms on contractor performance. In general, he found contractors were risk averters in terms of choice of sharing arrangement and in actual contract performance. Contractors were motivated to efficiency when faced with the possibility of incurring a financial loss due to tight cost targets, a narrow negotiated profit margin, a high contractor cost share, and cost uncertainty. The government was able to achieve this only when it had an unusually strong bargaining position due to competitive circumstances. However, weapon system and major subsystem producers frequently were successful in negotiating loose cost targets or weak sharing provisions when great cost uncertainty was present.[50] Otherwise, cost reduction opportunities were not exploited because of desires to maintain cost structures for future contracts, to preserve surplus personnel for future contracts, and safeguard other user costs.[51] Evidence also suggested profit maximization on a single contract could lead to the appearance of excess profits and such undesirable consequences as Government Accounting Office investigations, bad publicity, tougher government negotiating positions on future contracts, and generally poor customer relations.[52] According to Scherer, the government substituted direct controls and involvement in the contractor's internal operations when incentives had proven ineffective.[53]

Building on the two preceding works, Fox analyzed the management aspects of the weapons acquisition process and its resistance to reform. Following the earlier studies cited above, attempts were made to reform the contracting process, especially in the areas of

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[49]Ibid, pp. 132-145.

[50]Ibid, pp. 230-236.

[51]Ibid, pp. 239-242.

[52]Ibid, pp. 242-248.

[53]Ibid, pp. 373-377.

planning and budgeting, source selection, contracting methods, and program management.[54] Fox made several significant findings. He confirmed Scherer's findings that incentive contracts did not work as intended and that contractors were more concerned with preserving their cost structure than increasing profits.[55] He also found the government did not use competition to the extent that it could and that profit policy for negotiated contracts tended to penalize contractors for making cost reducing investments.[56] His most significant findings related to program control. He concluded government controls were necessary because defense contractors frequently failed to perform according to contract terms and had been lax themselves in maintaining adequate control over their programs. According to Fox, the level of control varies from little or no control for programs with little risk, firm fixed-price contracts, and no contract changes, to extensive controls for cost-reimbursement contracts or programs experiencing frequent changes.[57] However, he found that government program managers did not hold contractors to original contract terms, did not penalize them for default, and were not aggressive in trying to control program costs.[58] His overall conclusion was that the acquisition process was not committed to the efficient and effective management of resources (often penalizing efficiency and rewarding poor management) and was extremely resistent to reform.[59]

Gansler analyzed the impact of acquisition policies and practices on the defense industry. As a departure from previous studies, he did not limit his study to major weapons producers but included subcontractor and parts supplier levels as well. He based his research on data collected from the Congressional record, government-funded reports, DOD data, and

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[54]Fox, pp. 1-2.

[55]Fox, pp. 240-242.

[56]Ibid, pp. 256, 317.

[57]Ibid, pp. 384-385.

[58]Ibid, pp. 385, 422-426.

[59]Ibid, pp. 449-450.

personal interviews at the prime and subcontractor levels.[60] Gansler confirmed previous findings that the free-market system did not operate for defense acquisitions. As a result of this deficiency, and the abuses that have arisen, extensive regulations and management controls have been instituted which directly involve the government in the operating details of its contractors. He also found an adversary relationship prevails between the government and the defense contractor, in spite of the fact that there is a close, mutual dependence at the aggregate level.[61]

In terms of the overall effect of the defense contracting system on the defense industry, Gansler concluded the following:

> . . . at the prime contractor level only a few companies are doing a major share of the business, and these are using large amounts of government-supplied funds, plant space, and equipment. Additionally, most of the government procurement regulations and oversight practices are widely applied to this sector. . . . Thus, this prime-contractor level appears to already have almost total government involvement. The Department of Defense is the regulator, the specifier of new products, the "banker," the judge of claims, and almost the sole buyer. Data indicate that this detailed government intervention is grossly inefficient and frequently self defeating, yet a free market economy does not and probably cannot exist in this environment of a single buyer and a small number of suppliers.
>
> The opposite problem exists at the lower levels of the defense industry, among the subcontractors and parts suppliers. The smaller contractors . . . are required to supply their own plants, equipment, and money. Also, because of the way the government and the prime contractors do business, these smaller contractors are realizing a relatively low return on investment in comparison with the prime contractors and with small contractors in the civilian sector--frequently at a level where bankruptcy is common. . . As a result, large numbers of lower-level defense suppliers have been either going bankrupt or purposely leaving the defense business. . . . [62]

He further noted that the complexity of weapons systems prompt highly specialized subcontractors and parts suppliers, which combined with extensive barriers to entry, led to monopolistic and unresponsive suppliers.[63] Gansler also found a trend toward diversification into the civilian sector, especially by the largest contractors, making them less reliant on DOD

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[60]Gansler, p. 3.

[61]Ibid, pp. 72-73.

[62]Ibid, pp. 5-6.

[63]Ibid, pp. 6, 148-151.

business. However, they still fought to maintain their defense business because there are considerable incentives and exit barriers that prevent large prime contractors from leaving the defense industry.[64]

Adams examined the relationship between Congress, DOD, and defense contractors, focusing on the political activities of major defense contractors to strengthen their position in the contracting process. He defined the relationship between DOD and defense contractors as interdependent, intimate, one with the DOD rationing out contracts, preserving the profitability of major contractors, providing rent-free production facilities, and offering interest-free loans in the form of progress payments.[65] This suggests defense contracting is largely a political process and that defense contractors engage in such activities as personnel transfers to and from government service, political action committees, lobbyists, trade associations, and advertisements to influence that process to their benefit.

These studies suggest that the defense contracting process is a unique environment in which market forces do not generally operate and this leads to considerable inefficiencies. A quasi-market situation exists where firm fixed-price contracts are used for stable programs, especially when competition is involved. The further the defense contracting situation moves away from quasi-market control mechanisms, the more it approaches a bilateral monopoly with a non-market, quasi-administrative relationship characterized by government controls, competitive and contractual incentives, prices based on a function of costs, and public accountability reviews and audits. The defense contracting process has also been characterized as promoting inefficiency and being impervious to reform.

One notable reform that has taken place since the above research is a dramatic increase in the use of competition. As a result of the Competition in Contracting Act, the use of competition has become institutionalized. It created offices of competition advocacy to promote competition, created administrative requirements that make non-competitive

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[64]Ibid, pp. 39-43, 46-50.

[65]Gordon Adams, The Politics of Defense Contracting: The Iron Triangle (New Brunswick: Transaction Books, 1982) pp. 21-22.

contracting extremely difficult, and strengthened the disputes process to prevent abuses.[66] The military has dramatically increased the use of competition as shown in Table 3. This marks a shift in the buyer-seller relationship to greater reliance on quasi-market rather than government control mechanisms. According to the research cited above, for the contractors involved, that should result in less government control and greater incentive to improve efficiency.

Table 3

Use of Competition by Service

Service	FY82	FY83	FY84	FY85	FY86
Percentage of Contract Dollars Awarded Competitively					
Air Force	34.2	32.4	31.3	39.2	50.8
Army	40.3	41.5	42.0	46.9	53.1
Navy	26.7	29.0	37.5	44.7	51.9
Percentage of Contract Actions Awarded Competitively					
Air Force	72.2	74.9	78.0	82.2	89.9
Army	n.a.	48.2	56.8	61.5	81.8
Navy	29.9	40.0	50.3	69.2	72.8

SOURCES: U.S., Air Force, Office of the Competition Advocate General of the Air Force, Report to the Congress on Air Force Competition, 1986, pp. 2-3; U.S., Army, Office of The Competition Advocate General of the Army, Annual Report to Congress on Competition in Army Procurement, 1986, pp. 1-2; and U.S., Navy, Office of the Competition Advocate of the Navy, Navy Procurement Competition: FY 1986 Report to Congress, 1986, pp. ii-iii.

The defense contracting literature has served to describe the defense contracting process and the impact that process has on defense contractors, at least in an aggregate sense. It suggests variables that could be used in further research but does not provide a theoretical basis for such research except to suggest that traditional economic and market theories are

[66]Horton, pp. 131-132.

not applicable. The next section examines general systems theory and transaction cost economics as possible theoretical underpinnings for the defense contracting buyer-seller relationship.

Buyer-Seller Theoretical Models

This section draws upon systems theory and transaction cost economics to lay the theoretical foundation for developing a model of the defense contracting buyer-seller relationship. General systems theory can be used to focuses on the linkages that exist between the buyer and the seller and how the two systems interact with and impact each other. Transaction cost economics concentrates on the contractual arrangements that govern and define the buyer-seller relationship. Each provides a useful insight to defining the relationship between buyers and sellers.

A Systems Approach

One way to better understand the buyer-seller relationship and the impact defense contracting requirements have on the contractor's operations is to examine the relationship as two linked systems. Churchman suggested the systems approach, used by scientists to study and comprehend scientific phenomena, could be effectively applied to the study of government, business, industry and human problems.[67] Ashby deductively developed a model showing how living systems can be fully joined such that one system reacts mechanistically to disturbances from the other or how independencies can be achieved such that the system reacts only to selective disturbances, adapting more quickly to achieve stability than the fully joined system.[68] Building on Ashby's work, Glassman defined how the degree of coupling between living systems affects stability.

> The degree of coupling, or interaction, between two systems depends on the activity of the variables which they share. To the extent that two systems either have few variables in common or if the common variables are weak

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[67]C. West Churchman, The Systems Approach (New York: Dell Publishing Co., Inc., 1968).

[68]W. Ross Ashby, Design for a Brain (London: Chapman & Hall, Ltd., 1960) pp. 148-157.

> compared to other variables which influence the system, they are independent of each other. It is convenient to speak of such a situation as one of loose coupling and also to note that insofar as one system, A, is independent of another, B, we may speak of the persistence of the behavior of A in the face of the behavior of B.[69]

Glassman made provision for stronger and weaker variables such that two systems connected by weaker variables are more loosely coupled than systems connected by the same but stronger variables.[70] He suggested loose coupling can be maintained actively, such as when the system defends itself against disruptive influences; or passively, such as when a system insulates itself such that it only responds when variables gain limited access.[71] Glassman and Weik both applied the concept of loose coupling and persistence to organizational systems.[72]

In order to determine the degree of coupling between the government and the contractor, the number and strength of the variables connecting them must be identified. Landeros built upon Glassman's and Ashby's frameworks to model the buyer-seller relationship. He considered three types of relationships. A loosely coupled relationship is one in which the relative independence of the parties is maintained through open market bargaining. A tightly coupled relationship involves cooperative, buyer-seller relationships. A fully coupled relationship is analogous to backward integration with the source of supply internally integrated within the organization. He suggested five components determine the degree of coupling in a buyer-seller relationship: (1) the number of suppliers in the supply pool, (2) the amount of credible commitment, (3) the manner in which disputes are resolved,

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[69]Robert B. Glassman, "Persistence and Loose Coupling in Living Systems," Behavioral Science 18 (March 1973): 84.

[70]Ibid. p. 85.

[71]Ibid. p. 92.

[72]See Glassman, pp. 90-91; Karl E. Weik, "Educational Organizations as Loosely Coupled Systems," Administrative Science Quarterly 21 (March 1976): 1-19; Karl E. Weik, The Social Psychology of Organizing 2nd ed. (Reading, Mass.: Addison-Wesley Publishing Company, 1979) pp. 111-112.

(4) the flow of communication, and (5) the manner in which the two parties adjust to marketplace conditions.[73]

This provides a useful framework for evaluating defense contracting buyer-seller relationships, especially in terms of the supply pool, credible commitment, and communication involved. The Competition in Contracting Act has greatly increased the government's use of competition, and thus a move toward more loosely coupled relationships. This is especially so when there are numerous suppliers available. That also represents the use of credible threats as opposed to credible commitments to prompt contractor performance. Where competition is less possible, such as in the production of a major weapon system, both parties tend to be committed to each other, resulting in a tighter coupling. The amount of communication between the government and the contractor can vary substantially. During a competitive awarding process, communication prior to award is strictly controlled. After award, communication is usually minimal and is limited to contacts with the buying and administrative office personnel, especially contract surveillance, quality, and transportation representatives. For negotiated contracts for complex systems, communication is extensive before and after contract award. Minimum reporting requirements are frequently specified in the contract. Such contracts are also characterized by extensive communication with multiple functional representatives such as program managers, engineers, technical representatives, etc. in additional to the normal contracting officer's representatives. Thus, the amount of communication also describes the degree of coupling in a defense contracting environment.

The other two components are somewhat applicable but not as useful. Dispute resolution in government contracting is a fairly standard and formalized process that applies to all contracts and therefore may not be as meaningful as it would be in defining commercial buyer-seller relationships. Market place adjustment is somewhat problematical since the DOD's requirements are driven by defense needs and congressional appropriations. As these

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[73]Robert Landeros, "An Empirical Study of Buyer/Seller Relationships in U.S. Manufacturing Firms" (Ph.D. dissertation, Michigan State University, 1988) pp. 4-8.

requirements change, they are immediately passed on to defense contractors in the form of a change in the frequency and size of contracts awarded or, if current contracts are affected, by change notices, schedule changes, terminations, etc. and settlement costs are determined by negotiation or disputes. For large weapons programs, there may be some joint resolution activities but for the most part, contractors are left to cope with changing demand and conditions on their own. This does not mean that these components are not applicable to defense contracting. Rather, they are not as useful in defining the contracting relationship as they might be in the commercial sector.

Such a systems approach concentrates on how tightly the buyer's system is joined to the seller's system. In the government's case, fewer available suppliers, greater communication, and strong commitments to each other would signal tighter coupling between the defense contractor and the government. According to the systems theory described above, a contractor that is more tightly coupled to the government than another would be subject to greater government influence and control over its internal operations. This is consistent with the findings by defense contracting research that suggests prime contractors producing complicated products with limited competition, requiring extensive negotiation during the award process and for subsequent changes, and whose factors of production are highly specialized toward defense production face contract situations with extensive government controls. The opposite holds for contractors producing stable products with extensive competition, requiring little negotiation or communication, and using less specialized factors of production.[74] However, there is another approach to buyer-seller relationships that focuses more extensively on the contractual relationship between the parties that is in considerable harmony with the approach proposed by Landeros.

A Transaction Cost Economics Approach

Williamson developed a Transaction Cost Economics (TCE) model which matches transactions to appropriately structured contractual relationships in such a way as to

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[74]Gansler, pp. 5-6.

economize on production costs and transaction costs.[75] Transaction costs are those associated with drafting, negotiating, and safeguarding the agreement (ex ante) as well as costs associated with maladaption, negotiating contract modifications, resolving disputes, and bonding costs to secure commitments (ex post).[76] TCE relies on the following propositions:

1. The transaction is the basic unit of analysis.
2. Any problem that can be posed directly or indirectly as a contracting problem is usefully investigated in transaction cost economizing terms.
3. Transaction cost economies are realized by assigning transactions (which differ in their attributes) to governance structures (which are the organizational frameworks within which the integrity of a contractual relation is decided) in a discriminating way. Accordingly:
   a. The defining attributes of transactions need to be identified.
   b. The incentive and adaptive attributes of alternative governance structures need to be described.
4. . . . implementing transaction cost economics mainly involves a comparative institutional assessment of discrete institutional alternatives--of which classical market contracting is located at one extreme; centralized hierarchical organization [vertical integration] is located at the other; and mixed modes of firm and market organization are located in between.
5. Any attempt to deal seriously with the study of economic organization must come to terms with the combined ramifications of bounded rationality and opportunism in conjunction with a condition of asset specificity.[77]

Prior to discussing how TCE matches transactions to appropriate contract governance structures, it is necessary to understand the behavioral assumptions and the attributes of transactions that TCE considers.

Transaction Cost Economics relies on two behavioral assumptions. The first, bounded rationality, assumes that individuals intend to act rationally but are limited by their ability to solve complex problems and process information.[78] That is, individuals generally cannot foresee and plan for all possible contingencies. The second assumption is referred to as opportunism and refers to the prospect that some individuals resort to guile, deceit,

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[75]Oliver E. Williamson, "Transaction Cost Economics: The Governance of Contractual Relations," The Journal of Law and Economics 22 (October 1979): 245-246.

[76]Oliver E. Williamson, The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting (New York: The Free Press, 1985) pp. 20-21.

[77]Williamson, Economic Institutions, pp. 41-42.

[78]Oliver E. Williamson, "The Economics of Organization: The Transaction Cost Approach," American Journal of Sociology 87 (1981) p. 553.

information distortion, lying, stealing, and/or cheating in their self-improvement efforts. TCE is especially concerned with the more subtle forms of opportunism relating to incomplete or distorted disclosure of information.[79] In addition to these behavioral assumptions, one must also consider the attributes of the transaction in order to determine the most appropriate contract governance mechanism.

According to Williamson, there are three principal dimensions that characterize transactions. The first, and most significant dimension is asset specificity. This refers to the degree that the transaction requires special purpose investments in terms of sites, physical assets, human assets, and dedicated assets. The more transaction specific assets are, the less they can be converted to alternate uses and thus subject the owner to greater risk.[80] The second dimension is uncertainty, which refers to unforeseen disturbances as well as those arising from the presence of opportunism. The presence of uncertainty increases in importance when asset specificity is involved.[81] The third dimension is the frequency of transaction occurrence. The costs associated with specialized governance structures are more easily recovered for transactions of a recurring nature.[82]

The behavioral assumptions and the characteristics of the transaction interact to determine the contracting model that is most appropriate. Williamson considered four contracting models described as planning, promise, competition, and governance. He assumed that uncertainty is present (otherwise the problem becomes trivial) and considered the interaction of bounded rationality, opportunism, and asset specificity as they relate to the four models. These interactions are illustrated in Table 4.

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[79]Williamson, Economic Institutions, p. 47.

[80]Ibid, pp. 52-56.

[81]Ibid, pp. 52-56.

[82]Ibid, pp. 60-61.

Table 4

Attributes of the Contracting Process

Bounded Rationality	Opportunism	Asset Specificity	Contracting Process
0	+	+	Planning
+	0	+	Promise
+	+	0	Competition
+	+	+	Governance

SOURCE: Oliver E. Williamson, The Economic Institutions of Capitalism, p. 31.

Williamson first considered cases in which only one factor did not apply, as illustrated in Table 4. He argued that without bounded rationality, planning is most appropriate since unlimited ability to foresee all potential problems facilitates the creation of a comprehensive contract describing all possible contingencies. When opportunism is absent, contracts proceed efficiently because each party agrees to a general clause that unforeseen problems will be resolved in a joint profit maximization effort. Neither takes advantage of the other and both seek only the fair return each is rightfully entitled to in the spirit of the initial agreement. Contracting in this sense is based on promise. If asset specificity does not apply, competition can be used efficiently and courts can be relied on to deter opportunistic behavior. However, when all three conditions are present, planning, promise, and competition break down and a specialized governance structure is required. Transaction Cost Economics matches transactions to contractual governance structures in such a way as to "economize on bounded rationality while simultaneously safeguarding them against the hazards of opportunism."[83]

Given the presence of bounded rationality, opportunism, and uncertainty, TCE suggests that the appropriate governance structure depends on frequency and asset specificity. The competitive marketplace is most efficient when general-use assets are required, regardless of the frequency of the transaction. Parties to the transaction are

[83]Ibid, pp. 30-32.

independent and rely on competitive market forces to protect each other from opportunism. If one becomes dissatisfied, the relationship is terminated in favor of another trading partner.[84] At the other extreme, when highly specialized assets are required, especially for recurring transactions, vertical integration is more efficient than interfirm trading because economies of scale can just as easily be obtained by the buyer, adaptions are much easier, and transaction costs much lower. However, there are also disadvantages in the form of serious incentive and bureaucratic limitations which must be considered.[85]

In between these polar alternatives are intermediate governance structures that are more efficient when a mix of specialized and general purpose assets are required. As asset specificity increases, market contracting gives way to other governance structures since the buyer and seller become more committed to each other and to the transaction. The supplier is more committed because alternative uses for the assets are more limited and the buyer faces higher switching costs. Both can achieve economies by maintaining the relationship. However, the hazards of opportunism grow as well. Mechanisms must be incorporated to provide for adaptation while safeguarding against opportunistic behavior.[86] As uncertainty increases, this becomes even more pronounced.

> Whenever investments are idiosyncratic in nontrivial degree, increasing the degree of uncertainty makes it more imperative that the parties devise a machinery to "work things out"-since contractual gaps will be larger and the occasions for sequential adaptations will increase in number and importance as the degree of uncertainty increases. This has special relevance for the organization of transactions with mixed investment attributes. Two possibilities exist. One would be to sacrifice design features in favor of a more standardized good of service. Market governance would then apply. The second would be to preserve the design but surround the transaction with an elaborated governance apparatus....[87]

The most appropriate intermediate governance structure depends on the transaction's frequency of occurrence.

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[84]Ibid, pp. 73-74.

[85]Williamson, Economic Institutions, pp. 76, 78, 163.

[86]Ibid, pp. 62-63.

[87]Oliver E. Williamson, "Transaction-Cost Economics," p. 254.

Williamson suggested that a trilateral governance structure is most efficient for transactions involving mixed or highly specific assets but whose frequency of occurrence does not warrant the costs of establishing a transaction specific governance structure. In such cases, reliance is made of a third party to arbitrate disputes. However, when transactions are recurring enough to warrant a specialized governance structure, a bilateral governance structure is warranted. Here, the parties to the transaction remain autonomous and, since assets are not highly specific enough to warrant vertical integration, production economies of scale may be realized, strong incentives are maintained, and bureaucratic disabilities avoided. However, problems associated with opportunism and adaptation must be addressed. This may be done through automatic or routine contract adjustment mechanisms, depending on the threat of opportunism present. The parties can also agree to forego adjustments in areas where opportunistic behavior is too much of a threat. Credible commitments (transaction specific investments, posted bonds, reciprocal arrangements, etc.) can be created to establish the required confidence to safeguard the relationship.

Williamson's theory appears to be generally applicable to defense contracting. Its underlying behavioral assumptions are relevant. The complexity and uncertainty associated with defense contracting suggest bounded rationality is an appropriate assumption. The possibility of opportunism is suggested by the amount of contracting regulations that have been created to correct system abuses.[88] Defense contracting generally follows the contracting pattern described by TCE. Although the government does use some government owned and operated arsenals as well as government owned contractor operated production facilities, it generally relies on bilateral contracts with private industry to obtain its weapon systems and spare parts. Competition and fixed price contracts are used for products requiring standardized equipment and where uncertainty is not too great. As the production effort begins to require more specialized assets and involves greater uncertainty, quasi-administrative control mechanisms are substituted for market mechanisms. Concerning the

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[88]Fox, pp.350-351; Gansler, pp. 72-73.

suggestion that only recurring transactions can support such a highly specialized governance structure, Williamson states the following:

> Defense contracting may appear to be a counterexample, since an elaborate governance structure is devised for many defense contracts. This reflects in part, however, the special disabilities of the government to engage in own-production. But for that, many contracts would be organized in-house. Also, contracts that are very large and of long duration, as many defense contracts are, do have recurring character.[89]

TCE provides a good theoretical base for understanding defense contracting buyer-seller relationships, especially in regard to the level of government control that is incorporated into the contracting relationship.

Summary and Relation to Research

This literature review has examined three bodies of knowledge, the JIT literature, the defense contracting literature, and two theoretical approaches to buyer-seller relationships. The objective of this review was to ascertain what is known concerning the application of JIT by defense contractors and to develop the conceptual and theoretical basis for modeling the implementation of JIT in a defense contracting environment.

The JIT literature addressed the implementation of JIT in a defense contracting environment in a very limited way and there has been no empirical research in that area. Even though a consensus definition of JIT is lacking, the literature did provide models that can serve as useful frameworks for analysis. The Heard model was used in this research. The literature generally suggested the philosophy and techniques of JIT can be applied across a wide range of industries and environments. A few cases were cited where defense contractors have successfully implemented JIT to some degree and achieved significant benefits. However, implementation problems associated with those efforts were not addressed. Research has indicated, however, that companies generally experience problems with customer schedule changes, quality, and achieving supplier support. A review of defense contracting practices suggested contractors are also likely to experience problems in those areas. Specifically, their efforts to develop structured flow paths, people leverage, and

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[89]Williamson, Economic Institutions, p. 73, footnote 1.

linear operations are likely to be successful while efforts to achieve continuous flows and dependable supply and demand may be impacted by extensive government regulations in those areas.

The defense contracting literature suggested that contractors are subject to considerable uncertainty and government intrusion into their internal operations. In an aggregate sense, the literature suggested the highly regulated and controlled contracting process does not promote the production efficiency, capability, nor responsiveness needed in the defense industrial base to meet the requirements of the Department of Defense. The dilemma posed is the need for productivity improvement in a situation that often discourages or impedes such improvements. The literature also suggested, however, that there are situations where less government controls are exerted and where contractors are motivated to efficiency, such as with fixed price contracts with tight cost targets and high contractor cost share ratio, especially if competition is involved. Thus, some contract arrangements may be more conducive to JIT than others. The defense contracting literature also served as a source of variables that could be used to model the defense contracting environment.

The buyer-seller models suggested by Williamson and Landeros provided theoretical underpinnings for modeling the defense contracting buyer-seller relationship. Such relationships can range from an independent, loosely coupled relationship based on quasi-market, competitive governance mechanisms to a tightly coupled relationship with extensive government administrative control mechanisms. According to Williamson, the governance structure is a function of uncertainty, frequency, and asset specificity, with asset specificity being the most significant followed by uncertainty. Landers suggests the degree of coupling between the buyer and the seller is a function of the supply pool, communication, commitment, dispute resolution, and market adjustment. The first three are especially useful in describing the defense contracting relationship. These models provide the theoretical constructs for the conceptual model developed in the next chapter.

CHAPTER 3

CONCEPTUAL MODEL

DOD contracting policies, regulations, and requirements will likely impact a defense contractor's JIT efforts to some degree. The extent of the contracting requirements and the degree of DOD involvement in, and control over, a company's internal operations depends on a host of factors and can vary by contract and by contractor. As the contractual relationship moves from a loosely coupled, independent one based on market control mechanisms to an increasingly tighter coupled, interdependent one, the contractor becomes subjected to more and more government administrative controls. The contractor's freedom to unilaterally pursue JIT becomes diminished and that may affect the extent and success of those efforts. A conceptual model of this relationship is depicted in Figure 2.

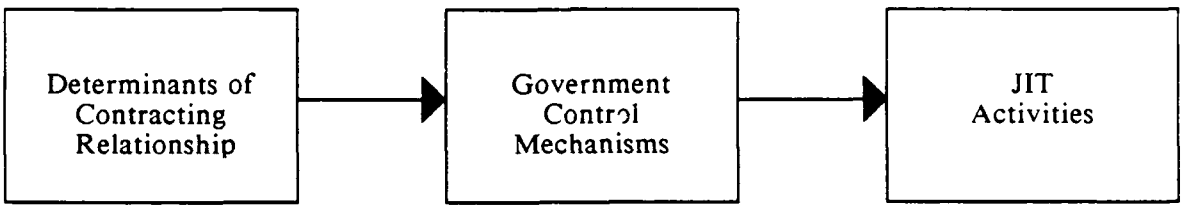

Figure 2. Model of JIT in Defense Contracting Environment

Determinants of the Contracting Relationship

The defense contracting literature and the two buyer-seller models discussed in the previous chapter suggest factors that influence the contracting relationship. The buyer-seller models provide the theoretical framework. In this study, the focus is on the level and type of controls that DOD places on defense contractors who are producing defense related items. Therefore, the theoretical constructs are defined in terms of defense contracting elements.

Theoretical Framework

Williamson's transaction cost economics provides the overall framework for this model. He suggests that for frequent transactions, the most efficient method of governance depends on the uncertainty surrounding the transaction and the extent to which highly specialized assets are required to carry out the transaction. Defense production contracts are usually of a recurring nature. Even if they were not, Williamson has suggested the government's use of elaborate governance structures is usually warranted because of its almost total dependence on private industry and the duration and size of its contracts.[1] Thus, uncertainty and asset specificity are the two main theoretical constructs to be considered. As uncertainty and asset specificity increase, the need for specialized contract provisions increase and the ability to rely on market mechanisms decrease. To the extent that parties make credible commitments to each other to facilitate the exchange, administrative control mechanisms can be reduced accordingly.

Relevant aspects of the model proposed by Landeros can be incorporated into the theoretical framework as well. Three of his factors were used in the research: the supply pool, communication, and commitment. Supply pool relates to asset specificity because as required assets become more and more transaction specific, the supply pool shrinks. The concept of commitment relates directly to the concept of credible commitments used in transaction cost economics. Communication relates to uncertainty. As uncertainty increases there is a corresponding need for increased communication. As the supply pool shrinks, as

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[1]Williamson, Economic Institutions, p.73, footnote 1.

commitments are made, and as communication levels increase, then the buyer and seller become more tightly coupled together. In the defense contracting environment, that means the government has greater interest in, and a tendency to exert greater control over, the seller's internal operations. That also corresponds to more elaborate governance structures to control the contract relationship.

Defense Contracting Elements

The theoretical framework outlined above must be operationalized in terms of defense contracting elements that can be observed. The elements selected here to represent the theoretical constructs are based on the defense contracting research reviewed in the previous chapter. These elements define the contract relationship and combine to determine the extent that government administrative controls are used to govern the relationship. Contracting elements are specified for contract requirements uncertainty, cost uncertainty, asset specificity, and commitment.

Contract Requirements Uncertainty

The general uncertainty surrounding the requirements of the contract is a result of the technological uncertainty inherent in the product to be produced and the changing nature of defense requirements for the product arising out of changing threats, policy changes, budgetary uncertainties, etc.[1] These are reflected in the requirement for communication before and after contract award. When the contract is for a well-defined product subject to little uncertainty, the contract can be awarded with little or no negotiation and only minor contract changes, if any, occur after contract award. Products subject to high levels of uncertainty require extensive negotiation prior to contract award and major contract modifications after award. The following two variables indicate the uncertainty of contract requirements and extent of communication required:

> Preaward Negotiation: The extent that negotiation is used in the contract award process.

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[1]Peck and Scherer, pp. 44-54.

Postaward Negotiation: The extent that negotiation must be used to modify the contract to reflect for contract changes that occur after contract award.

Cost Uncertainty

Cost uncertainty, according to Scherer, is the most important single factor influencing the choice of contract type.[2] Although there are a large variety of contract types, there are two broad categories, fixed-price and cost-reimbursement contracts. Fixed price contracts are used when cost uncertainty is not too great and contractors are willing to assume greater risk in exchange for the opportunity for higher profit. Cost-reimbursement contracts are used when there is considerable cost uncertainty and represent an assumption of greater risk by the buyer; therefore, greater administrative control is involved. In addition, incentive, or cost sharing, provisions can be included to further define the risk of the parties. In such contracts, cost targets are negotiated and deviations from those targets are shared proportionately in accordance with a negotiated sharing ratio. Additionally, the contract amount is also an indicator of cost uncertainty and represents relative risk for both parties. Accordingly, as the contract value increases, so does the amount of contracting regulations. Three variables are therefore used to define the cost uncertainty applicable to the contract.

Contract Type: Whether the contract is a fixed-price or cost-reimbursement type.

Government Share Ratio: The government's share can range from zero, in the case of a firm fixed-price contract, where the contractor assumes all the risk, to 100 percent for a cost-plus-fixed-fee contract, in which case the government assumes all the cost risk.

Contract Amount: The total contract price for a specific contract.

Asset Specificity

Three elements were chosen to reflect the degree to which specialized assets are required for the production effort. The first is the pool of available suppliers, or rather, the amount of competition for the contract. Extensive competition suggests the required assets are of a general nature and thus multiple sources are readily available. Highly specialized

[2]Scherer, p. 145.

assets result in a few or only one readily available source. The second indicator of asset specificity is the contractor's dependence on DOD for the sale of the product. A high proportion of product sales to DOD indicates the product tends to be defense unique, with little or no commercial applications. Such a concentration of DOD related sales would be evidence of asset specificity and would be accompanied by greater controls than if sales were concentrated primarily among commercial customers. Products are defined as commercial if more than half of the product's sales are sold commercially and are exempted from numerous government requirements (ie. Cost Accounting Standards, Certified Cost or Pricing Data, etc.) The third element is the quality level specified in the contract. This represents asset specificity on two counts. First, there are three general quality levels, each representing a more specialized quality system that must conform to government requirements. Second, the quality level also reflects the product's overall characteristics (technical specification, complexity, criticality, and application) which are also indications of asset specificity. Table 5 summarizes FAR guidelines for applying quality requirements in terms of these product characteristics. Technical specifications range from off-the-shelf to Military-Federal specifications, and thus suggest the degree of specialization to the military. Complex items have quality characteristics not visible in the end item and require specialized quality procedures. Critical items are those whose failure would result in personnel injury or jeopardize a vital miliary mission. A peculiar item has only one application whereas a common item has multiple applications. The quality level is a surrogate measure of these characteristics. The degree of asset specificity is therefore represented by the following variables:

> Competition (Supply Pool): The extent of competition for the contract, ranging from many suppliers to sole source.
>
> Product Dependence on DOD: The extent to which the product's sales are concentrated among DOD customers.
>
> Quality Level: One of three quality levels, 1) Contractor Inspection, 2) Standard Inspection, or 3) Higher Level Quality Requirements (MIL-I-45208, MIL-Q-9858, or other higher level).

Table 5

FAR Quality Requirements Guidelines

PRODUCT CHARACTERISTICS		Off-the-Shelf	Commercial		Military-Federal	
			Non-Complex	Complex	Non-Complex	Complex
Non-Critical	Common	Contractor Inspection (FAR 46.202-1)			Standard Inspection (FAR 46.202-2)	
	Peculiar					
Critical	Common	Standard Inspection (FAR 46.202-2)			Higher Level (FAR 46.202-3)	
	Peculiar					

SOURCE: Summarized from FAR Table 46-1, p.46.204.

Commitment

The level of commitment is defined by two indicators. The first concerns equipment ownership. To the extent that contractors use their own equipment and facilities, substantial commitments are made and less administrative controls are required. However, when contractors use government-owned equipment and facilities, the government protects its interests by imposing administrative controls governing its care and use. The second indicator involves the use of progress payments, a common form of government financing. To the degree that progress payments are used, contractors commit less of their financial resources to the transaction, and the government applies administrative controls to protect its investment. The two variables that indicate the level of committed resources to the transaction are:

Asset Ownership: The proportion of equipment used that is owned by the government.

Progress Payments: The extent to which progress payments are used.

The Contracting Environment

The contracting elements discussed above define the defense contracting environment associated with a particular contract as modeled in Figure 3. This model suggests a contract falls somewhere on a continuum of minimal to maximal government control. The governance

mechanism ranges from quasi-market contracting to a specialized bilateral governance structure, falling just short of internalization. This corresponds to loosely coupled systems at one extreme and very tightly coupled (almost fully coupled) systems on the other. Where a contract lies at this continuum determines the extent to which the contractor is subject to government contracting policies, requirements, and practices, which are discussed in the next section.

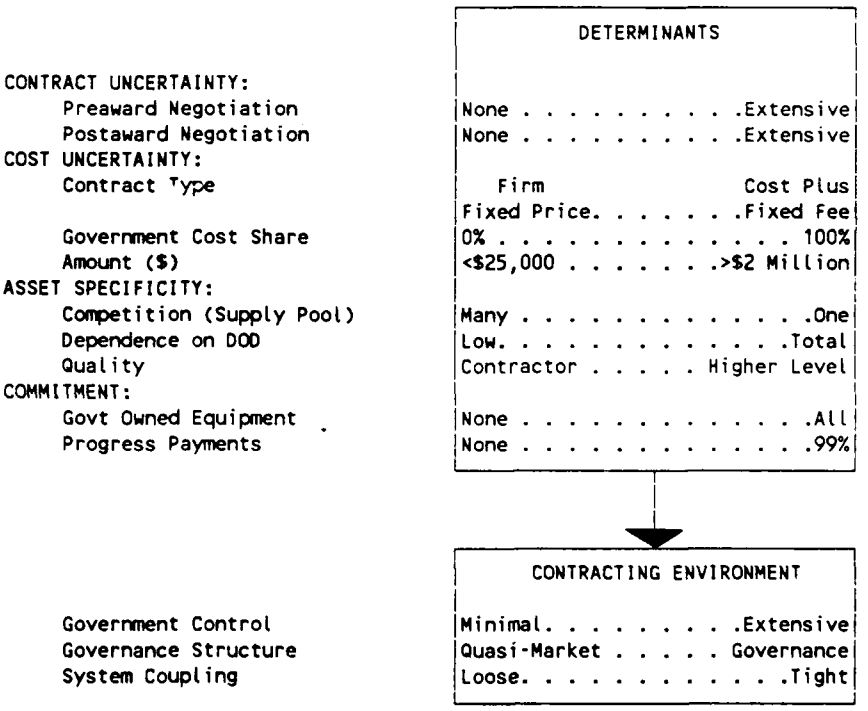

Figure 3. Model of Contracting Environment

Contracting Control Mechanisms

As discussed above, each contract varies in terms of the extent and magnitude of the administrative requirements and controls the government places on the contractor. This impacts not only the volume of controls, but in some cases, the degree to which the control mechanisms apply. This section presents a limited discussion of the types of requirements that may apply to a contract, and specifically, that might impact JIT efforts. Certainly, this cannot be done comprehensively, given the complexity of government regulations. Rather, it is intended to serve as a general framework.

The categories presented in this section were drawn from a variety of sources, including a review of FAR requirements and defense contracting research; interviews with defense contractor personnel, government contracting personnel, and consultants specializing in the defense industry; and the researcher's own government contracting experience. The categories, with a brief description are presented below:

Government Furnished Property. DOD occasionally provides government-owned material, special tooling, special test equipment, facilities (including equipment), and/or military property for use on specific contracts. Its use subjects the contractor to government requirements associated with the use, maintenance, and control of, as well as liability for, the applicable property as specified in Part 45 of the FAR.

Military Standards. These are DOD developed standards covering a wide range of categories including materials, processes, statistical sampling, work measurement systems, etc.

Government Controlled Specifications. The design and process specifications for a product can be controlled by DOD. In such cases, DOD reserves the right to change the specifications and to approve all contractor initiated changes.

Engineering Change Procedures. Changes or deviations from government controlled specifications require certain levels of government approval, depending on the nature of the change. Such procedures can be very involved and time consuming.

Value Engineering Procedures. Contracts over $100,000 in value typically have a value engineering clause which rewards the contractor for identifying design, process, or material changes that result in cost savings, as governed by Part 48 of the FAR.

Contract Quality Assurance Requirements. Contracts specify overall required quality inspection requirements (FAR Part 48) as well as specific tests and procedures that must be carried out. A contractor must show his quality

system satisfies general requirements as well as document required tests and inspections.

Government Quality Assurance Representative's (QAR) Policy and Requirements. These representatives determine whether contract quality requirements are met and also conduct intermediate and final inspections. QARs may be assigned to multiple contractors and/or products and therefore establish policies concerning the scheduling of inspections and tests.

Cost Accounting Standards. These standards govern the contractor's cost accounting and estimating practices. Modified standards are required for contract negotiations involving $100,000 or more. Full compliance is required when such contracts total $10 Million (net awards or one single award) in accordance with FAR Part 30.

Reporting Requirements. Some contracts require periodic reports concerning the contractor's efforts to perform the contract and can involve such things as costs, schedule, and quality (performance).

Contract Changes and Modifications. The government reserves the right to change, even terminate, the contract to meet its needs. Frequently changes are made and, if required, an appropriate settlement negotiated.

Contract Financing. DOD provides various forms of financing such as advance payments, loan guarantees, or , most commonly, progress payments as specified in FAR Part 32. With such financing comes controls to protect the government's interest.

Socioeconomic Programs. A whole FAR Subchapter deals with socioeconomic policies covering the use of small businesses and small disadvantaged businesses, (Part 19), firms in labor surplus areas (Part 20), and foreign suppliers (Part 25). It also governs the applicability of labor laws (part 22), environmental, conservation, and occupational safety laws (Part 23), and protection of privacy and freedom of information laws (Part 25).

Subcontracting Policy. Some contracts require government review and approval of the contractor's procurement planning process (Consent to Subcontract, FAR 44.2), plans to subcontract with small businesses (Subcontracting Plan, FAR 19.7), Make-or-Buy Program (FAR 15.7), and the overall purchasing system (Contractors' Purchasing Systems Reviews, FAR 44.3).

Government Specified/Approved Sources. In some cases, suppliers are limited by the government to specific sources or to a group of sources that have gone through an approval process. Contractors desiring to use different sources would have to have them approved, which can be an expensive and time consuming process for the contractor, the subcontractor, and the government.

Required Disclosure of Cost/Pricing Data: On some negotiated contracts (or contract modifications), contractors are required to submit cost or pricing data and may have to certify that it is complete, correct, and current (FAR 15.804) in accordance with the Truth in Negotiation Act (Public Law 887-653).

Government Audits/Investigations. DOD uses audits to verify costs and ensure compliance with government regulations. In addition, special audits and investigations are conducted when abuses are expected.

Defense Materials System/Defense Priorities System. A defense contract is assigned a rating which gives it priority over all lower rated defense orders and all commercial orders. This rating is passed on to all required materials and subcontracts.

Contract Delivery Requirements. All production contracts specify a required delivery schedule and may include allowances for variations in quantity, early or partial deliveries, liquidated damages for late deliveries, or acceleration/deceleration of the schedule.

Profit Policy. The government is concerned with a contractor's profit when contracts are negotiated and prices are not a result of competition or catalog/market prices. In such cases, the profit policy depends on the type of contract and is a function, at least in part, of anticipated and historical costs. The government's profit policy is an important consideration not only for the current contract, but for future contracts as well.

These categories represent broad contracting policy, procedural, and requirement issues that may impact a contractor's operations. To the extent that these apply, the government has greater involvement in the internal operations of a firm. Depending on the category, such government involvement could help, hinder, or have no impact on JIT implementation. If some of them become obstacles to JIT implementation, the JIT philosophy should prompt the contractor to work with government contracting personnel to eliminate the obstacle. If a contractor must obtain government approval for some JIT activities, the bureaucracy associated with the defense contracting process could slow down those JIT efforts.

JIT Implementation

The previous sections have focused on the determinants of the contracting environment and associated contract policies, practices, and requirements. These serve as parameters for JIT implementation. Of concern here are the JIT activities carried out in the implementation process and an assessment of the results of those activities. What is needed is a framework for comparing JIT activities.

The Heard model, which was introduced earlier, is a general model that is useful for describing JIT, especially in a manufacturing organization. Its five necessary conditions will

serve as a framework in this model. Four of the necessary conditions are used to describe JIT production efforts. They are reviewed below:

> Structured Flow Paths. This refers to the organization and layout of plant equipment to minimize material transportation and queue time. Tools that are used to accomplish this are layout improvement to minimize transportation, resource dedication, group technology, and focused factories.
>
> People Leverage. A work climate must be created to fully utilize the potential, capability, knowledge, creativity, and problem solving skills of all workers to eliminate waste and improve operations. Such tools as small group improvement activities, multiple machine handling, decentralized responsibility/ownership, and cross-trained, flexible workers are used to develop people leverage.
>
> Continuous Flows. This refers to efforts to achieve a continuous, uninterrupted flow of material. One way this is done is through Total Quality Control using such tools as statistical process control, line stoppage for abnormal conditions, developing foolproof mechanisms, process improvement, and worker responsibility for quality. Machine breakdown and troubles must also be eliminated through the use of preventive maintenance, machine improvement, and operator involvement in machine maintenance and problem detection.
>
> Linear Operation. A linear operation is one in which material flows are synchronized into stable, repetitive patterns of small lot production with each operation producing only the amount needed by the next operation. Activities that support this objective are setup time reduction, lot size reduction, conversion to a "pull" production control system, work-in-process inventory reduction, production leveling with quotas bases on the shortest time periods possible, and tight tolerance to schedule.

The activities used to achieve these necessary conditions describe in-house efforts to achieve JIT production. The fifth necessary condition involves the customer and the supplier to achieve further improvements.

The fifth element of Heard's model is dependable supply and demand. On the demand side, JIT promotes long-term, mutually beneficial partnerships with customers to achieve demand patterns and contract requirements conducive to JIT. The overall model developed in this chapter focuses on the impact the government, as a customer, has on JIT implementation. The major interest here is the contractor's efforts to achieve dependable supply through the use of JIT purchasing methods. The following activities are used to define JIT purchasing:

1. Supplier quality programs to achieve Total Quality Control
2. Supplier adoption of JIT
3. Reduction of supplier base to include only the best suppliers

4. Long-term partnerships/contracts
5. Increased use of single-sourcing
6. Geographical concentration of suppliers
7. JIT deliveries
8. Minimize receiving
9. Reduced administrative and paperwork requirements

Such activities focus on the development of long-term, JIT oriented supplier relationships that will produce the dependable supply necessary to eliminate the wastes associated with buffer inventories and unnecessary processing and handling.

Summary

This chapter has developed a model of JIT implementation based on the literature review of the previous chapter. The model has three components. The first identifies determinants of the defense contracting buyer-seller relationship. Williamson's transaction cost economics model provides the overall theoretical framework and is supported by Landeros' systems coupling buyer-seller model. Defense contracting elements were chosen to represent the cost uncertainty, overall contract requirements uncertainty, requirement for specialized assets, and commitment associated with the contractual relationship. The chosen elements combine to determine the amount of influence and control the government exerts over the defense contractor. This impacts the next component which defines the contracting policies, practices, and requirements which serve as parameters to the contractor and may or may not impact a contractors JIT efforts, the third component of the model. The JIT activities are defined in terms of the Heard model. The next chapter discusses the methodology used to conduct the research.

CHAPTER 4

METHODOLOGY

This chapter presents the research methodology used to assess the impact of government control mechanisms, in the form of contracting policies, practices, and regulations, on defense contractors' efforts to improve productivity and quality by incorporating the JIT philosophy into their production and purchasing operations. Specifically, this chapter discusses the research design, sample selection, variable selection and measurement, hypotheses, and statistical analysis used in the research.

Research Design

This study addressed the research questions summarized below:

(1) What characteristics of the contracting relationship significantly explain variances in 1) the impact of government control mechanisms, in the form of defense contracting policies, requirements, and practices, on JIT production and purchasing efforts and 2) the contractor's JIT production and purchasing efforts?

(2) What relationships exist between the defense contracting control mechanisms a contractor is subject to and the JIT production and purchasing activities undertaken?

A limited domain field study was undertaken to answer these research questions using the model shown in Figure 4, which is an expanded version of the model developed in the previous chapter. The first research question deals with the relationship of the contracting characteristics listed in the first box (which serve as predictor variables) with the elements of the other two boxes (which serve as sets of multivariate response variables). Hypotheses concerning these relationships will be discussed later in this chapter. The second research question concerns relationships between the contracting policies, practices, and requirements (second box) and the JIT activities (third box). This research question is of an exploratory nature. Expectations were developed but no hypotheses were postulated or tested.

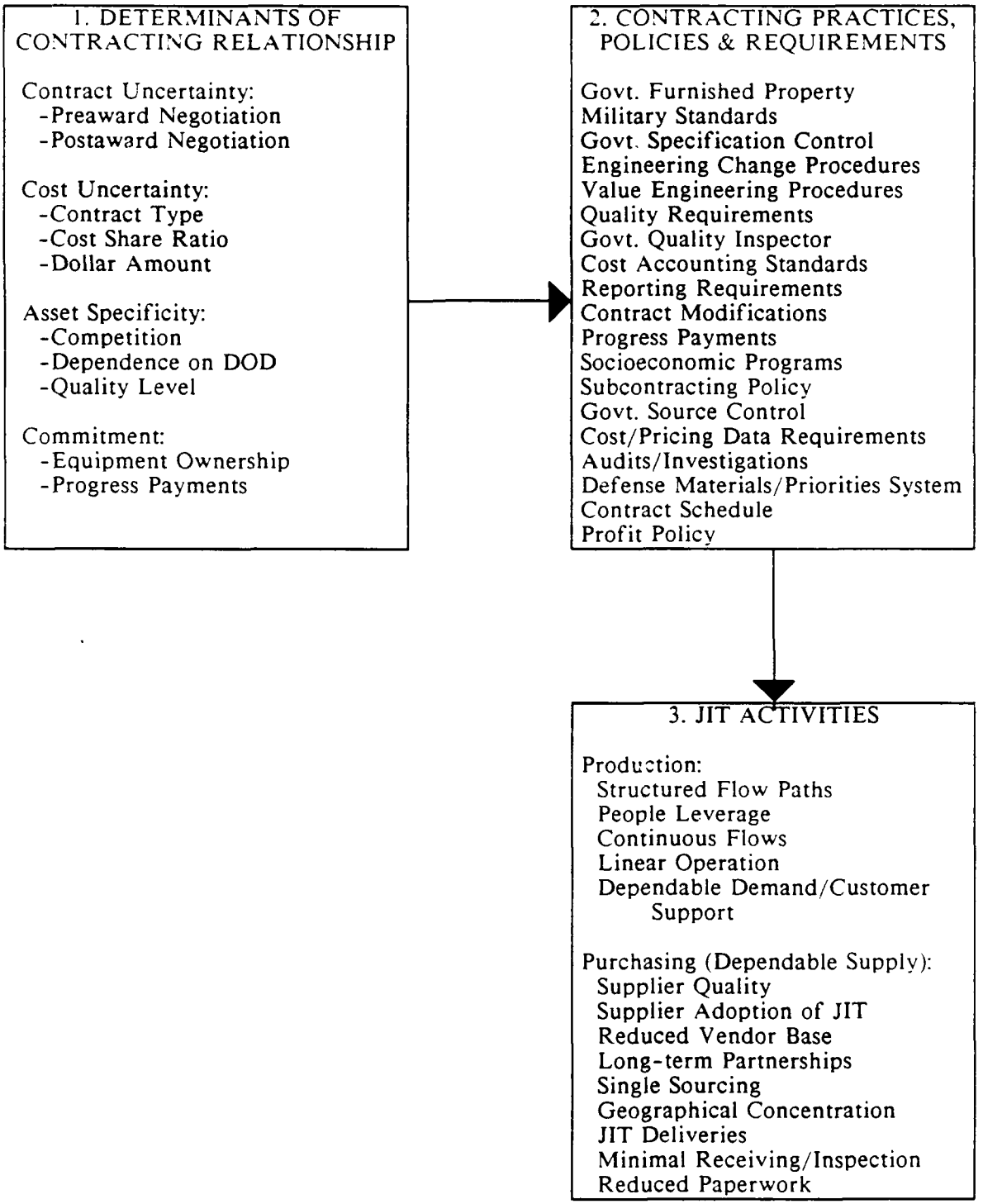

Figure 4. Extended Model of JIT in Defense Contracting Environment

It is important to note that this study was conducted in the vein of theory and model development as opposed to theory testing, in the strict sense of the word. The model illustrated in Figure 4, which served as the framework for the study, has some basis in theory and empirical research and some hypotheses were developed and tested. However, the tests conducted were used to further develop the model rather than test it. This is true for several reasons. Since the regressions were fitted to the data, the tests conducted ascertain the contribution of the variables to the model rather than serve as confirmatory tests. Further, confirmatory tests require large scale sampling of the population and the sparsity of defense contractors adopting JIT preclude large scale samples from being drawn. Second, research in the areas of defense contracting and JIT have been limited and do not provide the mature theoretical and empirical foundation for confirmatory testing. Finally, the model has not been refined to the degree necessary to accommodate confirmatory analysis nor large scale sampling. Thus, the focus of this study was to gain insight from the JIT experiences of five defense contractors and to refine the model for subsequent testing. This is consistent with the recommendations of Schendel and Hofer for research in emerging fields whose theoretical and research development is at an early stage.[1]

The limited domain for this study was necessary for several reasons. First, the number of known contractors having enough experience with JIT to permit a useful study was quite small. In addition, to control for extraneous variables, the domain was restricted to defense contractors (1) in the defense electronics industry, (2) with sales that place them among the largest 100 defense contractors, and (3) producing complex defense electronics products (not just commercial products sold to the government). In this way, the characteristics of contractors, products, and processes were as homogeneous as possible, which is important since observational data was used. The limited number of companies also permitted controls for company differences during data analysis. Furthermore, a limited domain narrows the range of contract relationships to be considered. The model developed

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[1]Dan E. Schendel and Charles W. Hofer, Strategic Management: A New View of Business Policy and Planning (Boston: Little, Brown and Co., 1979) pp. 383-390.

in the previous chapter considered a wide spectrum of contract arrangements ranging from loosely coupled relationships with minimum government control and maximum reliance on market mechanisms to tightly coupled relationships with extensive government control due to specialized contract governance structures associated with cost-reimbursable contracts. This study involved only fixed-price, production contracts. Therefore, this field study examined the efforts contractors in the defense electronics industry to implement JIT in a contracting environment that consists of intermediate levels of coupling and contract governance structures, as depicted in Figure 5. The selection of defense contractors to participate in the study is covered in the next section.

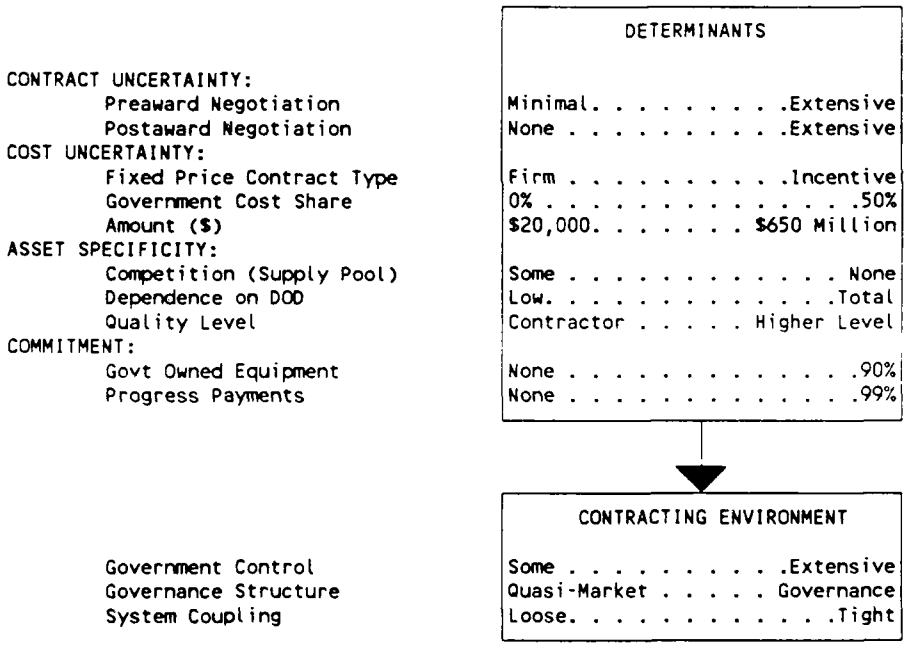

Figure 5. Research Model of Contracting Environment

Sample Selection

The following criteria were used to select companies to participate in the study. First, contractors were required to have JIT experience beyond that of a pilot project. Second, the contractors were required to produce defense electronics products to ensure they were operating in the same sector of the defense industry so that their products and processes were not highly dissimilar. Third, only companies among the top 100 defense contractors in terms of sales were considered to ensure that the contractors themselves were somewhat homogeneous, at least in terms of the overall contracting environment. Finally, since this was a field study, contractors were required to permit on-site interviews and provide access to the required contract data associated with each JIT project studied.

An extensive search for candidate companies was conducted by contacting defense industry consultants and individual defense electronics companies. Initially, five companies were targeted to participate. Each was invited to participate in the study and was guaranteed anonymity and confidentiality of data. One company met all the criteria except for not being one of the top 100 defense contractors. It was invited to participate in the pretest of the survey instrument and agreed to do so. Another company initially responded quite positively but later declined to participate because it considered its JIT activities to be proprietary because of their importance to its competitive position. The remaining three companies agreed to participate. Subsequently, two other companies were identified and invited to participate and agreed to do so, making a total of five companies plus a pretest company. Four of the companies had multiple divisions and plants using JIT. Plant sites were spread over four states located in three geographical regions. All produced complex electronics products although the range of complexity ranged from specialized printed wiring boards to complete systems. The technologies and processes used by the companies were generally very similar. The overall contracting environments were also similar for most of the companies. All were subject to extensive Military Specifications, were either MIL-I-45208

or MIL-Q-9858 certified, and were subject to Cost Accounting Standards and audits. Most had resident government contract administration/audit personnel and had certified purchasing systems. Thus, for the most part, they faced similar overall environments.

In spite of the similarities, there was a wide assortment of individual contracting situations, which was useful for this study. Table 6 gives an overall summary of contract information for the 29 JIT projects evaluated. As the table shows, the contracts associated with the JIT projects cover a fairly wide range in nearly every category, but especially so in terms of contract amount, use of government property, proportion of product sales going to DOD, and the contractor's estimate of the number of competitors it faces to get defense contracts. Most of the products were sold to DOD on firm-fixed-price contracts and required a MIL-Q-9858 quality level. Still, over a third of the products had other than DOD as the primary customer and used no progress payments. Concerning the individual companies themselves, by agreement with the companies, this level of data cannot be provided for each individual company. However, general profiles of the companies are provided in the following paragraphs.

Company A has three divisions in three separate facilities, all of which were primarily associated with government products. Interviews were conducted at two of the divisions. Twelve JIT production efforts and 10 supporting purchasing efforts were examined. Contracts associated with those products ranged from a low of $135,000 to a high of $52 million. Three contracts were fixed-price with cost incentive mechanisms (FPI) with the remainder being firm-fixed-price (FFP). Three products could be classified as commercial. The rest were government unique. Generally, company A used its own facilities and equipment with the proportion of government property ranging from 0 to 25 percent. The number of competitive producers ranged from none to eight. The company has been working with JIT for over 5 years as part of a corporate-wide program. Its approach has evolved from

Table 6

Aggregate Contract Information for Sample

Characteristic	Mean	Minimum	Maximum	Std Error
Contract Amount ($ Millions)	141.76	0.02	650.00	39.78
Progress Payment Rate (if used,%)	86.89	70.00	99.00	1.78
Defense Sales to Total Sales (%)	87.21	15.00	100.00	4.91
Government Property to Total (%)	19.41	0.00	90.00	4.95
Number of Competitors	2.0	0.00	10.00	0.59

Characteristic	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Contract Type				
Firm-Fixed-Price	25	86.2	25	86.2
Fixed-Price-Incentive	4	13.8	29	100.0
Quality Level				
Contractor Responsibility	3	10.3	3	10.3
MIL-I-45208	3	10.3	6	20.7
MIL-Q-9858	23	79.3	29	100.0
Use of Progress Payments				
No	10	34.5	10	34.5
Yes	19	65.5	29	100.0
Primary Customer				
DOD	19	65.5	19	65.5
DOD Prime Contractor	3	10.3	22	75.8
Other Government	3	10.3	25	86.2
Commercial	4	13.8	29	100.0

an inventory program, to a manufacturing program, to an all-encompassing program that includes all functions and activities, even support/overhead activities. Company A also has a Total Quality Control program that works hand-in-hand with its JIT efforts. Company A has a structured approach to JIT implementation, using outside consultants for initial training and to serve as facilitators to get individual teams going in the right direction. Internal

"champions" are used to keep things going. The company has restructured its performance and measurement system to include measurements of cycle time, inventory turnover, and quality.

Company B has two business groups with three separate facilities. Interviews were taken at all three facilities. Six JIT production efforts were examined along with four associated JIT purchasing efforts. All contracts were firm-fixed-price, ranging from $15 million to $650 million. All products were defense products with no commercial sales whatsoever. The facilities and equipment were primarily contractor owned although every contract used some government equipment ranging from 5 to 33 percent of the total facilities and equipment in use. The number of competitors ranged from none to ten. The JIT initiatives started six years ago in one area and three years ago in another. Each initiative was internally motivated and executed, each with different reasons and somewhat different approaches. The primary focus has been on internal production and material management, although some JIT purchasing activities have also been extensive.

Company C has three highly autonomous groups which participated in this study. Each had separate and extensive facilities. Seven JIT production projects and 6 JIT purchasing efforts were examined. All contracts were FFP and ranged from $39 Million to $495 million. The products examined had no commercial applications. The use of government facilities and equipment ranged from 1 percent to 90 percent. One of the facilities was a government-owned-contractor-operated (GOCO) facility. The contractor was in a sole source position on all except one contract (which had one competitor). This company uses a JIT "champion" at the corporate level to act as a consultant to the various groups and to disseminate information. The JIT implementation is initiated and controlled within the groups themselves. The approach has been geared mostly to the production areas with some purchasing applications. Efforts are also underway to apply the JIT philosophy to all activities, such as improving engineering and proposal cycle time.

Company D was different than the rest. Only one production facility was visited. The JIT effort underway there was self initiated by the operations manager. All contracts were FFP and were mostly of a low dollar amount ($20,000 or so). Commercial applications were dominant, with only 30 percent of its sales to DOD or prime contractors. No government property was used and the company faced extensive competition for the defense products produced. There were no resident government quality representatives, contract representatives, nor auditors, as there were in the other companies.

Company E has two divisions pursuing JIT and both participated in the study. Each had one production and purchasing JIT effort underway. The contracts ranged from $48.8 million to $434 million and included FFP and FPI contracts. Defense sales for the products ranged from 90 to 99 percent, leaving very few commercial applications. Very little government property was used, ranging from none to 5 percent. Competition was also at a low level, ranging from none to one competitor for government contracts. The overall approach has been to combine JIT activities with investments in automated equipment and computer integrated manufacturing, much of which has resulted from Technology Modernization (TechMod) and Industrial Modernization Improvement Program (IMIP) projects. This was done in response to corporate initiated requirements to reduce WIP, improve asset utilization, and increase profit.

Each of the companies that participated in the research were extremely cooperative in providing the required contract information and scheduling interviews with individuals knowledgeable about the JIT efforts. All interviews were conducted at each contractor's facilities. The intent was to examine every JIT project underway at each facility visited. However, that was not possible since some were deemed too sensitive or were classified. Thus, the researcher had to rely on the willingness of the contractor to provide the required access. In addition, some JIT projects could not be connected to particular contractual arrangements and were not useful for the study. Thus, the JIT projects that are included in

this study are a subset of projects underway. Random selection was not possible, but they are believed to be representative of each contractor's experience.

Data Gathering

Structured interviews were used to gather data from the companies that agreed to participate in the study. Forty production interviews and 24 purchasing interviews were conducted. Each company selected the person most knowledgeable about the JIT experience for each project. Usually the production interviews were with program managers and/or production project leaders, although in a few cases, production managers were interviewed. Purchasing interviews were conducted with purchasers or material specialists associated with each project. In addition, unstructured interviews were given to quality, production, purchasing, and division managers to obtain overall perspectives on the successes and the problems associated with implementing JIT in a defense contracting situation. This section will focus on the structured interview and the operationalization and measurement of variables.

Development and Pretest of Interview Instruments

Three interview instruments were developed for this study. One was used to gather the contracting information that was used as the predictor variables. Two were developed to gather information regarding the response variables for production and purchasing respectively. The first drafts of the instruments were developed from the research model depicted in Figures 4 and 5, which served as the framework for variable selection. The individual variables were defined and discussed in Chapter 3. The focus here is how they were operationalized and measured in field survey instruments.

The initial field survey instruments were pretested by conducting mock interviews with faculty and students at Arizona State University. Many of the students used were MBA students and had experience working either in production or purchasing for local defense

contractors. These interviews served two purposes: 1) to determine if the questions were easily and consistently understood by the respondents, and 2) to develop the appropriate protocol for conducting the interviews in an efficient and expeditious manner. They resulted in the rewording of a number of questions and a change in the format of the interview document.

The pretest was also used to develop the cards that contained the Likert scales used by the respondents to answer some of the questions. The respondents were given a choice of formats and the ones chosen most often were used in the study. The cards were then color coded so that both researcher and respondent could ensure the appropriate card was being used for each question. The name of the color was written on the card in case any of the respondents had difficulty with the colors. The cards were also laminated so that the same sets of cards could be used in all the interviews. Thus, each respondent received identical cards so their responses would not be influenced by extraneous factors. These actions were taken to improve the validity of the responses.

After the interview instruments were reworked, and the appropriate response cards selected, the process was again repeated with faculty and students at ASU. Next, actual interviews were conducted at the pretest company and another company that volunteered to participate in the pretest. Data was collected, coded, and input into the computer to test the coding scheme which was included on the interview documents. As a result of this portion of the pretest, final alterations were made to the documents. The final version of the documents used to gather actual data can be found in Appendix A. The next section describes how the interviews were conducted.

Interview Protocol

All interviews were conducted in person at each contractor's facility. Usually, the interviewer was introduced to the respondent by a company employee serving as an escort.

All companies, and therefore respondents, were aware that the researcher was an active duty Air Force officer working on a Ph.D. However, civilian business attire was worn instead of a military uniform to put the respondents more at ease. The interview materials consisted of the interview instrument; 5 1/2" X 8 1/2" laminated, color-coded, response cards; and a microcassette recorder. A cover sheet was used to record information about the product and the respondent. Whenever possible, this was filled out beforehand. If not, it was filled out at the beginning of the interview.

At the beginning of each interview, the respondent was asked for permission to record the interview as a check against mistakes and to streamline the interview. Most agreed without hesitation but some elected not to be recorded. Next, a printed introduction was read which introduced the purpose for the interview and guaranteed the respondent complete anonymity. The respondent was advised not to provide any proprietary or classified information. The respondent was then asked if he/she had any questions. The interview was then administered. At appropriate points, cards were provided to the respondent and he/she would be asked to select the appropriate response. Upon conclusion of the interview, the respondent was thanked, offered the right to receive a summary of the research findings, and asked for any concluding questions or comments. During the entire time, the interviewer coded responses and took notes for subsequent analysis.

This protocol was used for all interviews, even unstructured ones. Sometimes the contracting interview was held separately with a contracts person and sometimes it was combined with the production interview. The purchasing interview was always done separately. The content of the specific interviews, including variable operationalization and measurement are discussed next.

Contracting Interview

The contracting interview gathered data relative to the contracting environment associated with each JIT project. These data served as predictor variables in the study. Some of the contract characteristics were quite objective in nature because they were specified in the contract. Others required a subjective assessment by the respondent. When the JIT effort could be readily tied to a specific product, the respondent was asked to answer the questions based on a typical contract. If the JIT effort involved a number of products, the respondent was asked to answer the questions on the basis of the contract characteristics for the major products involved. In such cases, a subjective assessment had to be used for variables that would normally be objective in nature and verifiable by referring to a contract. The predictor variables were chosen to represent contract requirements uncertainty, cost uncertainty, asset specificity, and commitment.

Contract Requirements Uncertainty

Two variables represent the uncertainty surrounding the overall requirements for the contract, 1) Preaward Negotiation (PRENEG) and 2) Postaward Changes/Negotiation (POSTNEG). Both required a subjective assessment on the part of the respondent using a seven point Likert scale. The first involved an assessment of the extent that negotiation was typically used in the contract award process. The second involved the magnitude of changes occurring after contract award and required an assessment of the amount of postaward negotiation required to adjust the contract, using the same scale. Respondents were given a card with the following responses and were asked to choose the one that best described the negotiation in question:

1. No negotiation required.
2. The least extensive negotiation effort this company undertakes.
3. Somewhat less than average.

4. About average.

5. Somewhat above average.

6. Considerably above average.

7. The most extensive negotiation effort this company undertakes.

Cost Uncertainty

Cost uncertainty is reflected by 1) the type of contract (KTYPE), 2) the government's cost share ratio (GSHARE), and 3) the dollar amount of the contract (AMT). This study involved only fixed price production contracts, so only one of the first two variables were needed. Contract type can be determined from the government's cost share ratio, which defines the proportion of cost deviations (both positive and negative) for which the government is at risk. For a firm fixed-price contract, the government's share is zero. Any amount above zero indicates an incentive contract. The respondent was asked for the sharing arrangement, if any, and the government's share was recorded as a percentage. The contract dollar amount is a continuous variable and was recorded as $ millions.

Asset Specificity

Asset specificity is represented by three variables 1) Competition or Supply Pool (COMP), 2) Product Dependence on DOD (DEFSALES), and 3) Quality Level (QUAL). Competition was be measured by having the respondent estimate the number of competitors it faces for the product(s) in question. Product dependence was defined as the ratio of total DOD related sales of the product (including sales to prime contractors) to total product sales. The number was recorded as a percentage. The quality level is specified in the contract and consisted of five levels 1) Contractor Responsibility, 2) Standard Inspection, 3) Higher Level (Non-DOD), 4) Mil-I-45208, and 5) Mil-Q-9858. Levels 2 and 3 did not occur on any contract and therefore were eliminated and two indicator variables were used (Q2 for MIL-I and Q3 for MIL-Q).

Commitment

Two variables are used to represent commitment. The first is the proportion of the facilities, tooling, and equipment used on the contract that is government owned (GPROP). The respondent was asked to estimate that proportion and the number recorded as a percentage. The second variable involves progress payments (PROG). The payment rate, if any, is specified in the contract and was recorded as a percentage with a zero indicating no progress payments were used or provided. In the regressions, this variable was subsequently converted to an indicator variable (PROGPAY) with 0 indicating no progress payments and a 1 indicating progress payments were used.

Controls

In addition to the variables above, some variables were used to control for extraneous variables. First, four indicator variables (CO1, CO2, CO3, and CO5) were used to control for differences in company unique cultures that could impact JIT efforts. Second, the number of months that JIT has been implemented (JTIME) was used to control for differences in experience. There could be differences in responses depending on JIT experience. Finally, information was gathered concerning the primary customer for the product, the Department of Defense (DOD), a prime contractor (PRIME), other government agencies (OTHER), or commercial (COM). In addition to these controls, the contractors selected for the study are all defense electronics firms and are among the top 100 defense contractors in terms of defense business to achieve some homogeneity of processes, products, and overall defense contracting environment for these contractors. This was done to achieve as much control as possible, given that observational data was used, in the spirit suggested by Campbell and Stanley.[2]

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[2]Donald T. Campbell and Julian C. Stanley, Experimental and Quasi-Experimental Designs for Research (Boston: Houghton Mifflin Co., 1963) pp.34, 57.

Production and Purchasing Interviews

The production and purchasing interviews followed essentially the same format to obtain the response variables for the study. The first set of response variables involve 19 categories of defense contracting policies, practices, and requirements (G1-G19). Their selection and definitions were discussed in Chapter 3. They are listed here for reference.

G1 Government Provided Property	G11 Contract Financing
G2 Military Standards	G12 Socioeconomic Programs
G3 Govt. Control of Specifications	G13 Subcontracting Policy
G4 Engineering Change Procedures	G14 Govt. Control of Sources
G5 Value Engineering Program	G15 Cost/Pricing Data
G6 Contract Quality Reqts.	G16 Govt. Audits/Investigations
G7 QA Representative's Policy	G17 DMS/DPS (Priority System)
G8 Cost Accounting Standards	G18 Contract Delivery Reqts.
G9 Reporting Requirements	G19 Profit Policy
G10 Contract Changes/Modifications	

The respondents were asked to assess the impact of each practice on their overall JIT effort using a seven point likert type scale with the following possible responses:

0. Not applicable on this contract.

1. Strong negative effect.

3. Moderate negative effect.

4. No effect.

5. Some positive effect.

6. Moderate positive effect.

7. Strong positive effect.

Following each response, the respondent was asked to provide a rationale for their response. The same set of questions were used for both production and purchasing. For analysis purposes, the responses were reverse scaled so that a strong positive effect received a score of 1 and a strong negative effect a score of 7. The scaling then represents a progressively negative impact on JIT.

Occasionally, respondents had difficulty determining whether an answer should be no effect (4) or not applicable (0). They were able to say that the item in question did not impact them but were unsure about the appropriate response. In such cases, the interviewer, based upon the information provided by the contracts person and his knowledge of government contracting, would determine the appropriate response.

The second set of response variables assessed the contractor's JIT activities. They were grouped according to the Heard Model so as to define the contractor's efforts to achieve Heard's five necessary conditions. Separate sets of questions were used to assess production and purchasing efforts. A contractor's JIT production efforts were assessed through questions concerning the following activities:

- Structured Flow Paths
  - Layout improvement to minimize material movement
  - Dedication of resources to product lines
  - Application of Group Technology
  - Application of Focused Factory concepts
- People Leverage
  - Efforts to achieve cross-trained, flexible workers
  - Small group improvement activities (Quality Circles)
- Continuous Flows
  - Total Quality Control
    - Statistical Process Control
    - Line stoppage for defective conditions
    - Worker responsibility for quality
  - Total Productive Maintenance
    - Preventive Maintenance
    - Machine/Process Improvement
    - Operator involvement
- Linear Operation
  - Setup time reduction
  - Lot size reduction
  - Institution of a Pull System
  - WIP reduction
  - Linear/Drumbeat Production Schedule
- Dependable Demand
  - Negotiation of linear delivery schedules
  - Challenging Government Constraints
  - Reducing Administrative/Paperwork Requirements

Efforts to achieve dependable supply through JIT purchasing were assessed through the following.

Supplier quality improvement programs
Supplier training in JIT principles
Reduction in supplier base
Establishment of long-term partnerships/contracts
Use of single sourcing
Geographical concentration of suppliers
JIT deliveries
Minimization of receiving requirements
Efforts to reduce administrative and paperwork requirements

These JIT purchasing activities were be measured in two ways. First, respondents were asked to assess the freedom from government restrictions to pursue each activity using the following seven point scale:

1. Not restricted at all.
2. A little restricted.
3. Somewhat restricted.
4. Moderately restricted.
5. Somewhat heavily restricted.
6. Heavily restricted.
7. Completely restricted.

When restrictions were cited, the respondent was asked for a rationale.

The second measurement involved an assessment of the extent to which the JIT activities were being used, using the following seven point scale:

1. Not at all.
2. Very little.
3. Some.
4. Moderate.
5. Considerable.
6. Almost total.
7. Total.

Respondents were asked to describe their JIT efforts if any use was indicated.

This section has addressed the operationalization and measurement of the variables that were used in the study. The data were used to test the hypotheses concerning the relationship of the predictor variables to the sets of response variables and to explore the relationships between government contracting control mechanisms and JIT activities. The hypotheses of interest and expectations regarding the study are presented in the next section.

Research Hypotheses and Expectations

Two research questions were addressed in this study. The first involves relationships between the predictor variables and the response variables. It is restated here for convenience.

> (1) What characteristics of the contracting relationship significantly explain variances in 1) the impact of government control mechanisms, in the form of defense contracting policies, requirements, and practices, on JIT production and purchasing efforts and 2) the contractor's JIT production and purchasing efforts?

Hypotheses concerning this research question are advanced here and tested in the next chapter. The second research question involves relationships between the two response variables.

> (2) What relationships exist between the defense contracting control mechanisms a contractor is subject to and the JIT production and purchasing activities undertaken?

This research question is primarily exploratory in nature and no hypotheses were tested although some preliminary expectations are described.

Research Question 1

The research model (Figure 4, page 57, and Figure 5, page 59) assumes that increased levels of government control will impact a contractor's JIT production and purchasing efforts to some degree. The model suggests that the degree of requirements uncertainty, cost uncertainty, asset specificity, and contractor commitment that characterize the transaction determines the level of government controls that are imposed on a contractor. The

hypotheses concern the relationship between the characteristics of the contractual relationship and the restrictiveness of the contracting environment on JIT implementation and the extent of JIT implementation, in both the production and purchasing areas.

Contract Requirements Uncertainty

High degrees of uncertainty imply contractual gaps will be larger and the need for adaptation becomes more critical. Because of this, when assets are of a mixed to highly specific nature, elaborate governance structures are required to ensure the parties can adapt appropriately without jeopardizing the transaction.[3] As the uncertainty surrounding contracting requirements increases, government control mechanisms are added to protect the interests of the government. In addition, the need for communication between the parties increases which is reflected in the amount of negotiation required in the contract award process and to settle postaward changes to the contract. Overall, increased uncertainty over contract requirements leads to the need for tighter coupling and more extensive and specialized governance structures. This in turn impacts a contractor's JIT efforts. This leads to the following hypotheses:

H1: As the uncertainty of contract requirements increases (as manifested by the amount of preaward and postaward negotiation associated with the contract) the impact of government control mechanisms will increase and JIT efforts will be negatively affected.

H1a: At least one of the variables serving as indicators of contract requirements uncertainty will be significantly and positively related to the impact contracting policies and practices have on a contractor's overall JIT production efforts.

H1b: At least one of the variables serving as indicators of contract requirements uncertainty will be significantly and negatively related to the extent that JIT production is implemented.

H1c: At least one of the variables serving as indicators of contract requirements uncertainty will be significantly and positively related to the impact contracting policies and practices have on a contractor's overall JIT purchasing efforts.

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[3]Williamson, "Transaction Cost Economics," p. 254.

H1d: At least one of the variables serving as indicators of contract requirements uncertainty will be significantly and negatively related to the extent that JIT purchasing is implemented.

Cost Uncertainty

As cost uncertainty associated with a particular transaction increases, the risk to one or both parties of the transaction increase as well. When cost uncertainty is high, mechanisms are needed to mitigate the risk to protect both parties and facilitate the transaction. The negotiated sharing arrangement for deviations from target costs is an indicator of the uncertainty of cost estimates. If the contractor assumes all the risk such that the government's share is zero, all cost savings (and overruns) accrue to the contractor and fewer controls are needed. To the degree that risk is born by the government, controls are likely to be used to protect the government's interest. In similar fashion, as the dollar amount of the contract grows, the relative risk to both parties grow as well and appropriate governance structures become more affordable. Therefore, as cost uncertainty increases, government controls are also likely to increase and impact JIT efforts. The following hypotheses result:

H2: As cost uncertainty associated with a particular contract increases (as indicated by the government's cost share and the contract amount) the impact of government control mechanisms will increase and JIT activities will be negatively affected.

H2a: At least one of the variables serving as indicators of cost uncertainty will be significantly and positively related to the impact contracting policies and practices have on a contractor's overall JIT production efforts.

H2b: At least one of the variables serving as indicators of cost uncertainty will be significantly and negatively related to the extent that JIT production is implemented.

H2c: At least one of the variables serving as indicators of cost uncertainty will be significantly and positively related to the impact contracting policies and practices have on a contractor's overall JIT purchasing efforts.

H2d: At least one of the variables serving as indicators of cost uncertainty will be significantly and negatively related to the extent that JIT purchasing is implemented.

Asset Specificity

Asset specificity refers to the degree that specialized assets are used in the production effort. Highly specialized assets restrict competition and force the use of governance structures and more tightly coupled relationships to preserve the contract relationship. Three variables are used to indicate the degree that asset specificity applies to the defense contracting relationship, 1) the competition (Supply Pool) that is available, 2) the dependence on DOD as a customer for the product, and 3) the quality level specified in the contract. As asset specificity increases, government controls are also likely to increase which will increase the impact on JIT implementation. Therefore, the number of competitors should be inversely related to asset specificity and positively related to JIT efforts. The other two variables should be positively related to asset specificity and negatively related to JIT efforts. The following hypotheses will be investigated:

H3: As asset specificity increases (as manifested by decreasing competition, increasing dependance on DOD sales, and increasingly specialized quality requirements), the impact of government control mechanisms will increase and JIT efforts will be negatively impacted.

H3a: At least one of the variables serving as indicators of asset specificity will be significantly related to the impact contracting policies and practices have on a contractor's overall JIT production efforts. Dependence on DOD and Quality Level will be positively related while competition will be negatively related.

H3b: At least one of the variables serving as indicators of asset specificity will be significantly related to the extent that JIT production is implemented. Dependence on DOD and Quality Level will be negatively related while competition will be positively related.

H3c: At least one of the variables serving as indicators of asset specificity will be significantly related to the impact contracting policies and practices have on a contractor's overall JIT purchasing efforts. Dependence on DOD and Quality Level will be positively related while competition will be negatively related.

H3d: At least one of the variables serving as indicators of asset specificity will be significantly related to the extent that JIT purchasing is implemented. Dependence on DOD and Quality Level will be negatively related while competition will be positively related.

Commitment

Transaction cost economics suggests credible commitments to a transaction decrease the need for contract governance mechanisms because the commitments serve to motivate the parties to preserve the relationship. The Landeros model suggests such commitments indicate a tighter coupling exists. Commitments, then, serve to decrease the need for administrative control mechanisms that might otherwise be required when tight buyer-seller relationships are used. The two variables used to indicate the level of commitment by the contractor are asset ownership (the proportion of government property used) and the use of progress payments. These variables indicate the extent that government, rather than contractor, provided equipment and financing is used. As contractors use such equipment and financing, they become subject to government controls emplaced to protect the interests of the government. Thus the following hypotheses:

H4: As the contractors reliance on the government (in terms of assets and financing) increases, the impact of government control mechanisms will also increase and JIT efforts will be negatively impacted.

H4a: At least one of the variables serving as indicators of commitment will be significantly and positively related to the impact contracting policies and practices have on a contractor's overall JIT production efforts.

H4b: At least one of the variables serving as indicators of commitment will be significantly and negatively related to the extent that JIT production is implemented.

H4c: At least one of the variables serving as indicators of commitment will be significantly and positively related to the impact contracting policies and practices have on a contractor's overall JIT purchasing efforts.

H4d: At least one of the variables serving as indicators of commitment will be significantly and negatively related to the extent that JIT purchasing is implemented.

Expectations

The following expectations were set forth prior to conducting the research. Problems with multicollinearity among the predictor variables was anticipated for several reasons. First, this study used observational data which cannot be controlled so as to totally eliminate correlations. Further, multiple indicators are used for each theoretical construct, which also increases the possibility of collinearity. As a result, variables can often share the same information and make it difficult to interpret regression coefficients and determine statistical significance. Efforts to minimize the problems associated with correlated response variables can result in elimination of some predictor variables.

It was also anticipated that the variables emerging as most significant may or may not be consistent for all response variables. It would not be unreasonable to find predictor variables having strong relationships to some response variables and not others. For example, it could be that contracting elements impact purchasing activities differently than production activities. It was also considered possible that the effects of the predictor variables might diminish as one considers first the effect of contracting policies and requirements and then the extent of JIT implementation since other variables not included in the model could play a greater on JIT implementation. It was hoped, however, to find some consistency in relationships between predictor variables and all response variables.

Concerning the relative importance of the predictor variables in this model, Williamson's transaction cost economics approach suggests that asset specificity is the most important dimension of the transaction in terms of determining the most appropriate governance structure.[4] Therefore, one would expect that at least one of the three variables representing asset specificity would be a dominant variable in the model if contracting practices and policies do impact JIT implementation. Of the three variables, competition

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[4]Williamson, Economic Institutions, p. 52.

has been shown by past research to be an important force that prompts the conditions required to motivate contractors to efficiency.[5] Competition was expected to emerge as one of the most important variables, not only because of its motivational impact but because it also results in contracts with fewer government control mechanisms.

Uncertainty is also a significant dimension of the transaction that impacts the governance structure. Scherer found cost uncertainty is the most important factor influencing contract type.[6] To the degree that cost uncertainty is a significant factor influencing the governance structure, it would be expected that the government cost share ratio (which indicates the type of fixed price contract) would emerge as a significant variable in the model. Concerning the negotiation required due to the uncertainty of contract requirements, no expectations are made concerning the predominance of one over the other.

Commitment is a mitigating factor that can serve to modify the governance structure that would normally be required. This has been defined in terms of the contractor's use of government property and financing which brings additional government controls. It is likely that the impact associated with these variables will be moderate as opposed to predominant in nature.

Research Question 2

The second research question explores possible relationships between the contracting policies and requirements and the JIT activities in both the production and purchasing areas. This research question is primarily exploratory in nature and no specific hypotheses will be developed or tested. Instead the following research questions will be addressed:

R2a: Do government contracting policies, practices, and requirements have a greater impact on JIT <u>purchasing</u> activities than JIT <u>production</u> activities?

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[5]Scherer, pp. 102-107.

[6]Scherer, p. 145.

R2b: What relationships are there between contracting policies, practices, and requirements and JIT production activities?

R2c: What relationships are there between contracting policies, practices, and requirements and JIT purchasing activities?

Even though hypotheses are not developed, expectations can be discussed. The impact of government controls on JIT purchasing efforts is likely to be negative and fairly strong while their impact on JIT production is likely to be more moderate, although still somewhat on the negative side. The expected effects, in terms of direction and not magnitude, are summarized below for both JIT purchasing and production activities:

Contract Requirements	Production	Purchasing
Govt. Property	-	0
Military Standards	-	-
Govt. Specifications	-	-
Engineering Change Procedures	-	-
Value Engineering Program	+	+
Contract Quality Requirements	-	-
QAR Policy/Requirements	-	?
Cost Accounting Standards	-	?
Reporting Requirements	-	-
Contract Changes/Modifications	-	-
Contract Financing	-	-
Socioeconomic Programs	0	?
Subcontracting Policy	?	-
Govt. Specified/Approved Sources	?	-
Cost/Pricing Data	-	-
Govt. Audits/Reviews	-	-
Defense Materials/Priorities System	?	+
Contract Delivery Requirements	+	?
Profit Policy	-	-

These expectations were developed from preliminary interviews with defense contracting personnel, defense contracting personnel, and the researchers own analysis. Most of these requirements represent, to some degree, parameters to the contractor. For example, the use of government provided property, military standards, government controlled specifications, engineering change procedures, quality assurance requirements, QAR policy, Cost Accounting Standards, subcontracting policy, government specified sources, Defense Materials System/Defense Priorities System, and contract delivery requirements define

requirements JIT activities must conform to or change. Some of the others listed are mostly motivational in nature. These include contract financing, disclosure of cost or pricing data, submission to government audits/reviews, and profit policy. They do not necessarily impact JIT activities directly but can serve as disincentives.

This section has outlined the hypotheses and research questions of interest to this study. It has also described expectations associated with the research. The next section describes the statistical methodology used to test the hypotheses and answer the research questions.

Analytical Techniques

This section describes the analytical techniques used in the study. In general, multiple linear regression was used to test the hypotheses associated with the first research question. Two types of t-tests, nonparametric Mann-Whitney tests, and simple frequencies were used to answer the second research question.

The hypotheses to be tested involve relationships between the predictor variables and the various sets of response variables. The relationships of interest involve the predictor variables and an overall measurement, not the multiple responses, associated with each response variable. For each set of multivariate response variables, a principal component analysis was conducted. The first principal component, a linear combination of the response values which accounts for the greatest variation in the multivariate system, was used as an index for each set of responses. The coefficients of the principal component indicate the relative importance of each original variate. A univariate multiple regression of predictor variables on the principal component was used to determine the significance of each predictor variable in the model and its contribution to changes in the principal component values. In addition, the respondents were asked to provide an overall assessment for the response variable and a multiple regression was run as a check on validity.

The following steps were used to develop the model for each of response variable analyzed. First, a residual analysis was conducted using graphical techniques and criteria proposed by Hocking[7] to identify problems with data outliers and extreme points that might distort the linear regression. Several diagnostics provided by PROC REG in SAS, Version 5, were used. Leverage values (diagonal elements of the Hat Matrix) were used to locate observations with unusually large leverage, or influence, on the regression. using a criterion of 2p/n (where p = the number of parameters and n = the number of observations). Externally studentized residuals (R Student) were used to locate outliers, using a t statistic with (n-p-1) degrees of freedom as the criterion. The Difference in Fit Statistic (DFFITS) values were used to detect the combined effects of the R Student and Leverage values using a criterion of twice the square root of p/n. These diagnostics, plus plots of response variables on individual predictors, response variable against time, R Student against time, R Student against predicted value, and R Student against the square root of (Leverage/ (1-Leverage)), were used to assess the aptness of the model in terms of underlying assumptions concerning normality, homoscedasticity, and linearity. Second, collinearity was examined by analyzing regression coefficients, pair-wise correlations, variance inflation factors, and latent roots and vectors and consideration given to eliminating highly correlated variables.[8] Next, the multiple regression was conducted and the hypotheses were tested. Finally, a reduced models with only the most significant variables were developed using SAS PROC STEPWISE to obtain more parsimonious models.

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[7]R. R. Hocking, "Developments in Linear Regression Methodology: 1959-1982," Technometrics 25 (August 1983): 222-224.

[8]See John Neter, William Wasserman, and Michael H. Kutner, Applied Linear Statistical Models, 2nd ed. (Homewood, Ill.: Richard D. Irwin, Inc., 1985) pp. 390-393; and Edward R. Mansfield and Billy P. Helms, "Detecting Multicollinearity," The American Statistician 36 (August 1982): 158-180.

Several regressions were conducted. The first regressed the predictor variables on an overall assessment of the amount of government control the contractor is subject to for the particular product in question. This was used to validate the model by determining the contribution that the predictor variables make to the amount of control. The second involved the principal component for the assessment of the impact of contracting policies, practices, and requirements on a contractor's JIT production efforts and tested hypotheses H1a, H2a, H3a, and H4a. A regression involving the principal component for JIT production activities was used to test hypotheses H1b, H2b, H3b, and H4b. Similarly, regressions will be conducted for the principal components for the response variables associated with JIT purchasing.

The second research questions explores relationships between contracting requirements and JIT activities. In order to determine if contracting practices impact JIT purchasing activities more than JIT production activities (R2a), t-tests (with pooled and separate variances) and Mann-Whitney tests were conducted (using SPSS\PC+) on all shared response variables. These test whether the mean responses are significantly different with respect to purchasing and production respondents. The three tests have different underlying assumptions. The t-test with pooled variances assumes normality and equality of variance. The t-test with separate variances relaxes the assumption of homogeneous variance. The Mann-Whitney test relaxes the normality assumption. In order to be conservative, the highest p-value of the three tests was used. Responses to the open-ended questions associated with the impact of government regulations (G1-G19) and the relative freedom to conduct JIT activities (OF1-Of20, PF1-PF9) were analyzed and frequencies tabulated to determine relationships between government contracting practices and JIT production and purchasing activities. The results and findings of the analyses are discussed in the next chapter.

CHAPTER FIVE

RESEARCH RESULTS

This chapter presents the data analysis and research findings arising from the procedures described in the previous chapter. This includes both descriptive and statistical analyses of the data collected as they relate to the research questions and hypotheses outlined in Chapter 4. The first section presents the results of residual analyses and collinearity diagnostics which resulted in the elimination of some variables from the model. The next section presents the regression results and hypothesis tests used to answer the first research question. That section first examines relationships between predictor variables (contract characteristics) and response variables assessing the impact of government contracting control mechanisms on JIT production and purchasing efforts. Then the relationship between the contract characteristics and response variables evaluating the extent of JIT implementation in both areas. The third section examines the results of the study in regards to the second research question. That section first tests whether production and purchasing responses differ in any meaningful ways and then explores the mean responses and answers to open-ended questions concerning possible linkages between government contracting practices and JIT activities.

Residual and Collinearity Analyses

Residual and collinearity analyses were conducted for full and reduced regression models. The predictor and response variables were discussed in Chapter 4 and are summarized in Table 7. The purpose of these analyses was to identify data problems or severe violations of linear regression assumptions.

Table 7

Predictor and Response Variables

Variable Name	Description
Predictor Variables:	
CO1, CO2, CO3, CO4, CO5	Indicator variables for companies A, B, C, D, and E respectively. CO4 was used as the base category.
KTYPE	Indicator variable for contract type, 1 if Fixed-Price-Incentive contract, 0 if Firm Fixed Price.
PRENEG	A rating from 1 to 7 defining the extent that negotiation was required prior to contract award (1=None, 4=Average, 7=Most Extensive).
POSTNEG	A rating from 1 to 7 defining the extent that negotiation was required to change the contract after award using the same scale as above.
AMT	Contract amount in $ Millions.
Q1, Q2, Q3	Indicator variables for quality levels Contractor Responsibility, MIL-I-45208, and MIL-Q-9858 respectively. Q1 was used as the base category.
PROGPAY	Indicator variable for progress payments, 1 if progress payments were used, 0 if not.
GPROP	Percentage of facilities, tooling, and equipment used to produce the product that is government owned.
DEFSALES	Percentage of total product sales that is defense related.
COMP	Number of other companies that compete for DOD contracts for the product in question.
JTIME	Number of months since JIT implementation began.
DOD, PRIME, OTHER, COM	Indicator variables for primary customer being respectively the Department of Defense, DOD prime contractor, Other Government, or Commercial. COM was used as the base category.

Table 7--Continued

Variable Name	Description
Response Variables:	
OCONTROL, PCONTROL	A subjective assessment, using a seven point scale, of the amount of control the government exerts over the Production/Operations and Purchasing areas respectively (1 = No government control, 7 = Total government control).
OGPRIN1, PGPRIN1	The first principal components of variables assessing the impact of 19 government contracting control mechanisms (G1-G19) on JIT production and JIT purchasing efforts respectively.
PRODJIT, PURJIT	A subjective assessment, using a seven-point scale, of the overall extent to which JIT production and JIT purchasing have been respectively implemented (1 = Not at all, 7 = Totally).
OJPRIN1, PJPRIN1	The first principal components of variables assessing the extent of implementation of 20 JIT production activities (OJ1-OJ20) and 9 JIT production activities (PJ1-PJ9).

The initial full regressions had several problems indicating the need for variable reductions. The indicator variable OTHER was found to be a linear combination of other indicator variables and was thus eliminated from the model. Further, the large number of predictor variables caused the models to be severely over parameterized because of the relatively small number of observations, especially for purchasing. This caused some problems with the behavior of residuals.

The residual diagnostics identified two highly influential production observations that had a zero R Student value and a Leverage value of one, indicating they forced the regression line to pass through their data points. There were three such purchasing observations. An examination of plots of each response variable on each predictor variable did not show these points to be unusual. The large number of indicator variables with such a small sample resulted in some cases where one observation dominated one or more indicator

variables, thus forcing the regression mean for that value to its actual value. As a result of collinearity analysis, discussed later, several indicator variables were removed from the model and that corrected the problem. The diagnostics also identified other outliers and influential points exerting influence on the regression. The accuracy of the data points was checked and all were found to be correctly coded, valid observations. A comparison with the individual plots of response variables on predictor variables did not identify candidates for exclusion from the analysis. Rather, the data is characterized by a large dispersion of data points, due in part to variation in subjective assessments. Thus no observations were dropped.

The residual plots suggested that, in some cases, especially with the indicator variables, that the assumption of homogeneity of variance might be a problem. The data did not point to a need for transformation and none was attempted. In order to see if this might be a severe problem, residual plots were examined to assess the behavior of R Student values against Time and against the predicted value. In general, these plots did not suggest a problem with variance. The plots of R Student against time for OCONTROL and PCONTROL indicated the variance may have reduced slightly over time, but was not very pronounced. The plots of R Student against predicted value for those variables were fine. The possibility of heteroscedasticity is not as much of a problem in an exploratory setting as it is for confirmatory tests. However, significance levels can appear to be better than is actually warranted. That should be kept in mind when reviewing the p-values associated with the regressions.

Normal probability plots were also analyzed. They initially suggested the residuals for all purchasing response variables were not normally distributed. However when collinearity problems were corrected and the regressions performed with fewer variables, the normal probability plots improved significantly such that none of them suggested serious departures from normality. All reduced models had quite good normal probability plots. Since linear regressions and associated tests are quite robust against non-normality, that was not considered a problem for any of the regression models, full or reduced.

The collinearity diagnostics indicated that multicollinearity was a serious problem. Table 8 shows the variance inflation factors (VIF) for the full regressions. The values differ for some response variables because of missing observations. However, all consistently identify the same variables as causing variance inflation due to multicollinearity. The high variance inflation factors for CO1, CO2, CO3, Q2, Q3, and DEFSALES suggested these variables were causing the most problem, with CO5, DOD, and PROGPAY close behind. Eigenvalues and eigenvectors, which show combinations of variables that are highly correlated, identified CO1, CO2, CO3, CO5, Q2, Q3, and DEFSALES as the major sources of multicollinearity. The indicator variables for company were included as controls and are not variables of interest. Since they were causing problems with multicollinearity, they were dropped as predictor variables. The quality variables and DEFSALES both measure the same theoretical construct, asset specificity, so Q3 was kept in the model and the other two eliminated. The next most influential combination of variables included KTYPE, DOD, and PRIME. DOD and PRIME were controls and not variables of interest, so they were eliminated. The next combination included PROGPAY and COMP. Both were variables of interest and measured different theoretical constructs. Competition represented the most important construct so PROGPAY was eliminated. After these variables were eliminated, VIF values and collinearity diagnostics identified PRENEG and Q3 as still contributing to multicollinearity. PRENEG was eliminated from the model and with that step, all VIF values were under two, as Table 8 shows, suggesting multicollinearity was under control.

The model, when corrected for multicollinearity, also generated improvements in the behavior of the residuals. No observations were so highly leveraged so as to result in R Student values of zero and leverage values of one as was the case previously. Some outliers and extreme points remained, but they were fewer in number and the diagnostic values much more moderate. This was especially true for the purchasing response variables. The leverage plots did not suggest problems with unequal variances, with the exception of the plot of R Student values on predicted values for PGPRIN1, which had some indication of a decreasing variance. The next few sections discuss the regression results.

Table 8

Variance Inflation Factors

Predictor Variables	Response Variables: OGPRIN1 OCONTROL PRODJIT	OJPRIN1	PJPRIN1 PCONTROL PURJIT	PGPRIN1
Full Model:				
CO1	176.33	164.10	259.39	263.37
CO2	154.89	137.26	214.70	217.90
CO3	152.99	141.21	198.79	196.46
CO5	53.32	53.72	65.61	69.45
KTYPE	15.02	15.49	11.10	8.98
PRENEG	8.06	7.79	10.52	9.90
POSTNEG	4.49	4.51	6.54	5.71
AMT	6.84	6.70	4.04	5.71
Q2	87.69	87.45	218.84	241.99
Q3	242.51	237.30	556.16	590.59
PROGPAY	24.35	24.15	25.86	27.16
GPROP	5.27	10.71	7.08	6.48
DEFSALES	184.24	181.01	383.16	424.39
COMP	5.28	5.65	8.52	9.92
JTIME	4.22	4.64	2.75	3.08
DOD	44.85	43.08	48.95	68.08
PRIME	13.74	9.87	13.99	20.85
Corrected Model:				
POSTNEG	1.34	1.34	1.22	1.26
KTYPE	1.36	1.35	1.38	1.47
AMT	1.42	1.51	1.83	1.92
Q3	1.87	1.86	1.75	1.74
COMP	1.45	1.45	1.47	1.48
GPROP	1.54	1.67	1.94	1.76
JTIME	1.17	1.20	1.69	1.64

Research Question 1--Regression Results

This section presents the regression results used to determine the characteristics of the contracting relationship that significantly explain differences in 1) the impact of contracting control mechanisms and policies on JIT production and purchasing efforts and 2) the extent to which JIT production and purchasing activities are undertaken. Four general hypotheses and sixteen sub-hypotheses were developed in the previous chapter. The four general

hypotheses are repeated here for convenience. The sub-hypotheses are provided in the sections in which they are tested.

H1: As the uncertainty of contract requirements increases (as manifested by the amount of preaward and postaward negotiation associated with the contract) the impact of government control mechanisms will increase and JIT efforts will be negatively affected.

H2: As cost uncertainty associated with a particular contract increases (as indicated by the contract type and the contract amount) the impact of government control mechanisms will increase and JIT activities will be negatively affected.

H3: As asset specificity increases (as manifested by decreasing competition, and increasingly specialized quality requirements), the impact of government control mechanisms will increase and JIT efforts will be negatively impacted.

H4: As the contractors reliance on the government (in terms of assets and financing) increases, the impact of government control mechanisms will also increase and JIT efforts will be negatively impacted.

The regression coefficients and significance levels will be used to test these hypotheses. However, the tests are not conducted to accept or reject them as would be the case if this were a confirmatory experiment, but rather to indicate whether the hypotheses are supported or not. First, the impact of government contracting policies and practices will be addressed.

Regressions Concerning Government Controls

Four response variables are used to assess the impact of government control, namely OCONTROL, PCONTROL, OGPRIN1, and PGPRIN1. The first two variables are assessments of the overall level of control the government exerts over the contractor's production and purchasing operations. Table 9 provides a summary of the responses, which suggest purchasing activities are perceived as falling under greater government control than production activities, although the difference is not too pronounced. The next two variables are the first principal components of variables assessing the impact of 19 government contracting practices on JIT production and JIT purchasing activities, used here as overall indices of the impact of government controls, with higher values indicating increasingly negative impacts on JIT. The results of the principal component analyses are summarized in Table 10. OGPRIN1 represents the linear combination of the variables that represents the

Table 9

Descriptive Statistics for Government Control
Over Production and Purchasing Operations

Response:	OCONTROL		PCONTROL	
	Frequency	Percent	Frequency	Percent
1. No government control	0	0.0	0	0.0
2. Very little control	2	5.0	1	4.2
3. Some control	4	10.0	0	0.0
4. Moderate control	9	22.5	2	8.3
5. Considerable control	21	52.5	14	58.3
6. Almost total control	3	7.5	7	29.2
7. Total control	1	2.5	0	0.0
TOTAL	40	100.0	24	100.0
Mean	4.55		5.08	
Standard Error	.1639		.1797	

greatest amount of variation (40.5 percent) in the responses. It primarily represents variation in the impact of government owned property, government controls over specifications, government engineering change procedures, value engineering requirements, reporting requirements, and progress payments. PGPRIN1 does the same for JIT purchasing, representing 34 percent of the variation in responses, primarily government control over specifications, engineering change procedures, value engineering procedures, postaward changes to the contract, progress payments, and government sources. On a lesser scale, it also represents the impact of government auditors and quality inspectors.

Production Impacts

Multiple linear regressions on the response variables OCONTROL and OGPRIN1 were used to determine how the contracting environment impacts the overall level of control over production operations (OCONTROL) and the impact of government control mechanisms on JIT production (OGPRIN1). The results of these regressions are summarized in Table 11. They include full regressions with all predictor variables plus reduced models developed through the SAS PROC STEPWISE procedure, which permitted only variables with

Table 10

Principal Components--Impact of Government Controls on JIT Production and JIT Purchasing

Variable Definition	OGPRIN1 Eigenvector	PGPRIN1 Eigenvector
G1 Govt. property	0.3424	0.1640
G2 Mil-Standards	0.1144	0.0732
G3 Govt. control over specifications	0.4762	0.3704
G4 Engineering change procedures	0.5182	0.4191
G5 Value Engineering Program	0.3349	0.3216
G6 Contract quality requirements	0.0713	0.0158
G7 Govt. QA Representative (QAR)	0.0086	0.2672
G8 Cost Accounting Standards (CAS)	0.0768	-.0370
G9 Reporting requirements	0.2578	0.1457
G10 Contract changes/modifications	0.0890	0.3042
G11 Progress payments & controls	0.3830	0.3320
G12 Socioeconomic programs	-.0020	0.1105
G13 Govt. subcontracting policy	-.1094	0.0085
G14 Govt. specified/approved sources	0.0641	0.3837
G15 Disclosure of cost/pricing data	0.0796	0.1884
G16 Govt. audits/reviews	0.0808	0.2126
G17 Defense Materials/Priorities Systems	0.0031	0.1087
G18 Contract delivery requirements	-.0100	0.0428
G19 Govt. profit policy	-.0313	0.0242
Variation Explained (Proportion)	0.4054	0.3401
Mean	0.0000	0.0000
Minimum Value	-10.3831	-10.3217
Maximum Value	4.6691	5.3618
Standard Error of Mean	0.7007	0.8948

significance levels of .1 or lower to enter the model. For the reduced model, all variables except DEFSALES and indicator variables for company and customer were considered. These variables were excluded to keep multicollinearity under control. The four regressions, full and reduced models, were used to test the following hypotheses:

H1a: At least one of the variables serving as indicators of contract requirements uncertainty (PRENEG, POSTNEG) will be significantly and positively related to the impact contracting policies and practices have on a contractor's overall JIT production efforts.

H2a: At least one of the variables serving as indicators of cost uncertainty (KTYPE, AMT) will be significantly and positively related to the impact contracting policies and practices have on a contractor's overall JIT production efforts.

Table 11

Regression Results for Government Control Over Production
(Response Variables OCONTROL, OGPRIN1)

Model:	OCONTROL (N=40)		OGPRIN1 (N=40)	
Full Model:	F VALUE 2.155	PROB>F 0.0657	F VALUE 24.457	PROB>F 0.0001
	R-SQUARE .3204	ADJ R-SQ .1717	R-SQUARE .8425	ADJ R-SQ .8081
Variable:	PARAMETER ESTIMATE	PROB>|T|	PARAMETER ESTIMATE	PROB>|T|
INTERCEPT	4.0215	0.0001	-6.4787	0.0001
POSTNEG	-0.0361	0.7547	-0.0895	0.7076
KTYPE	-0.2719	0.5808	-2.8562	0.0078
AMT	-0.0008	0.3286	0.0012	0.4869
Q3	1.1336	0.0270	10.1657	0.0001
COMP	-0.0951	0.1126	-0.0838	0.4909
GPROP	0.0012	0.8596	-0.0156	0.2856
JTIME	0.0060	0.5627	-0.0340	0.1205
Reduced Model:	F VALUE 7.113	PROB>F 0.0024	F VALUE 86.491	PROB>F 0.0001
	R-SQUARE .2777	ADJ R-SQ .2387	R-SQUARE .8238	ADJ R-SQ .8143
Variable:	PARAMETER ESTIMATE	PROB>|T|	PARAMETER ESTIMATE	PROB>|T|
INTERCEPT	4.0558	0.0001	-7.2541	0.0001
KTYPE			-2.1673	0.0174
Q3	0.8752	0.0246	9.7796	0.0001
COMP	-0.0898	0.0842		

H3a: At least one of the variables serving as indicators of asset specificity (Q1, Q2, Q3, COMP) will be significantly related to the impact contracting policies and practices have on a contractor's overall JIT production efforts. Quality Level Q2 or Q3 will be positively related while competition (COMP) or Q1 will be negatively related.

H4a: At least one of the variables serving as indicators of commitment (PROGPAY, GPROP) will be significantly and positively related to the impact contracting policies and practices have on a contractor's overall JIT production efforts.

The response variable OCONTROL focuses on the overall level of government control over production operations. Thus, it only partially addresses the hypotheses. Response variable OGPRIN1 does address the hypotheses directly and is therefore the most important regression.

The regressions provide the strongest support for H3a. The regression on OGPRIN1 has Q3 as the most statistically significant variable ($p < .0001$) for both full and reduced models which themselves are significant at the .0001 level and account for 80 percent of the variation (Adjusted R-Square). The size of the regression coefficients also suggest that Q3 contributes roughly ten index points to the principal component value. Its sign is as hypothesized, giving strong support to hypothesis H3a. The regression on OCONTROL provides some support as well. The full model had Q3 as the most significant variable ($p = .0270$) and the sign of its coefficient was as hypothesized. However, a Bonferroni procedure to protect an overall significance level of .10 would require a p-value of 0.0142 or less to be considered significant. Further, the model, while significant at the .0657 level has an adjusted R Square of only .1717. The stepwise procedure found only two variables significant at the .10 level, Q3 and COMP, both of which lend support to H3a. The Adjusted R-Square indicates only about a fourth of the variation is explained. In addition, a Bonferroni procedure with two variables would require a p-value of .05, leading to the conclusion that COMP ($p = .0842$) is not statistically significant. These results suggest that asset specificity, in the form of the highest DOD quality requirement, is related to increased government controls on production in general and adversely impacts JIT production efforts, at least in the judgement of the respondents.

The remaining hypotheses received mixed or no support. H2a received mixed support from these regressions. KTYPE appears as the second most significant variable in both full and reduced models of OGPRIN1, but its sign is in the opposite direction than hypothesized. This suggests that contracts with cost incentives reduce the impact of controls on JIT production efforts. Thus, while cost uncertainty appears significant, its effect is opposite than that predicted. The regressions provide no support for hypotheses H1a or H4a.

None of the variables representing contract uncertainty or commitment had regression coefficients significantly different from zero and thus do not explain any variation associated with the overall level of control over production nor the impact of controls on JIT production, at least insofar as the respondents' assessments are concerned.

Purchasing Impacts

Similar regressions were conducted to determine the impact of the contracting environment on the purchasing area. Regressions on the response variables PCONTROL and PGPRIN1 were conducted to test the following hypotheses:

H1c: At least one of the variables serving as indicators of contract requirements uncertainty (PRENEG, POSTNEG) will be significantly and positively related to the impact contracting policies and practices have on a contractor's overall JIT purchasing efforts.

H2c: At least one of the variables serving as indicators of cost uncertainty (KTYPE, AMT) will be significantly and positively related to the impact contracting policies and practices have on a contractor's overall JIT purchasing efforts.

H3c: At least one of the variables serving as indicators of asset specificity (Q1, Q2, Q3, COMP) will be significantly related to the impact contracting policies and practices have on a contractor's overall JIT purchasing efforts. Quality Level (Q2, Q3) will be positively related while competition (COMP) and Q1 will be negatively related.

H4c: At least one of the variables serving as indicators of commitment (PROGPAY, GPROP) will be significantly and positively related to the impact contracting policies and practices have on a contractor's overall JIT purchasing efforts.

The regression results are summarized in Table 12.

As was the case with the previous variables, PCONTROL is an assessment of the overall level of government control over purchasing operations. The regression on PCONTROL did not result in any significant variables and thus did not support any of the hypotheses. Apparently, the characteristics of individual contracts are not related to the overall level of government control over purchasing, which is usually a centralized function and organized by purchased commodity rather than by product.

PGPRIN1 involves assessments of the impact of government controls on JIT purchasing efforts and it provided a more useful model. The full model had an overall

Table 12

Regression Results for Government Control Over Purchasing
(Response Variables PCONTROL, PGPRIN1)

Model	PCONTROL (N=24)		PGPRIN1 (N=22)	
Full Model	F VALUE	PROB>F	F VALUE	PROB>F
	0.541	0.7911	7.640	0.0007
	R-SQUARE	ADJ R-SQ	R-SQUARE	ADJ R-SQ
	.1915	-.1623	.7925	.6888
Variable:	PARAMETER ESTIMATE	PROB> |T|	PARAMETER ESTIMATE	PROB> |T|
INTERCEPT	5.9812	0.0001	-9.8490	0.0001
POSTNEG	-0.0519	0.7004	0.9969	0.0144
KTYPE	0.1177	0.8664	1.9128	0.3800
AMT	0.0014	0.3793	0.0015	0.7367
Q3	-0.3500	0.5632	4.8332	0.0056
COMP	-0.0881	0.2229	0.2527	0.1751
GPROP	-0.0067	0.4956	0.0483	0.0763
JTIME	-0.0092	0.4156	0.0172	0.5382
Reduced Model:			F VALUE	PROB>F
			29.047	0.0001
			R-SQUARE	ADJ R-SQ
			.8724	.8423
VARIABLE:			PARAMETER ESTIMATE	PROB> |T|
INTERCEPT	(No significant Variables)		-6.3301	0.0006
PRENEG			0.7345	0.0129
POSTNEG			0.4937	0.0828
Q1			-6.4740	0.0006
PROGPAY			2.3127	0.0216

significance level of .0007 which explained about 69 percent of the variation (Adjusted R-Square). The reduced model included four variables, all with appropriate signs. The overall model is quite good with a p-value of .0001 and an adjusted R-Square of .8423. Both full and reduced models provide some support for three of the hypotheses, H1c, H3c, and H4c.

H3c received the strongest support. In the full regression, Q3 was the most significant variable (p = .0056) and its regression coefficient was consistent with that hypothesized, suggesting that the highest quality level was associated with a negative impact of government controls on JIT purchasing. The reduced model had Q1 as its most significant variable (p = .0006) and its coefficient was also consistent, suggesting that the lowest quality level contributed to decreasing the impact of control mechanisms. Moreover, the size of the regression coefficients for the two variables suggested they contribute considerably to changes in the response variable, given that the other variables in the respective models remained constant. This provides solid support for H3c and suggests that asset specificity, in the form of specialized quality requirements, has a significant and negative impact on the effect of government controls on JIT purchasing.

H1c received quite strong support. Variables representing contract requirements uncertainty were the next most significant variables in both the full and reduced models. POSTNEG (p = .0144) had the hypothesized relationship but a Bonferroni approach controlling for an overall significance of .1 with seven variables would find it not quite statistically significant. Both PRENEG (p = .0129) and POSTNEG (p = .0828) are included in the reduced model with appropriate regression coefficients. Controlling for four variables and an overall significance of .10, a Bonferroni approach would require a p-value of .025 to be considered significant. Thus only PRENEG emerges as significant, supporting H1c and suggesting contract uncertainty, manifested primarily through the negotiation required to obtain the contract, is associated with an increasingly negative impact of government controls on JIT purchasing. However, the role of cost uncertainty as hypothesized in H2c was not supported at all. Apparently cost uncertainty is not related to the impact of government controls on JIT purchasing.

The reduced regression also supports H4c. PROGPAY (p = .0216) is the third most significant variable and has the hypothesized regression coefficient. It provides some support to hypothesis H4a, suggesting that contractors reliance on government progress payments is

associated with increased government control and an associated negative impact on JIT purchasing.

Regressions Concerning JIT Implementation

This section presents the regression results for the four response variables related to the extent to which defense contractors have implemented JIT production and purchasing, namely: PRODJIT, PURJIT, OJPRIN1, and PJGPRIN1. The first two variables are subjective assessments of the overall extent that JIT production and purchasing activities have been implemented. Table 13 provides descriptive statistics that summarize those responses. It appears that the implementation of JIT production is generally more advanced than that of JIT purchasing, at least according to the respondents' evaluations. Most of the projects surveyed began in the production function with purchasing involvement occurring later, if at all. The next two variables are the first principal components of response variables assessing the extent that 20 JIT production activities and 9 JIT purchasing activities were implemented. The principal components are here used as an overall index of variation in those assessments, with higher values indicating more extensive implementation.

The results of the principal component analysis are summarized in Table 14. OJPRIN1 and PJPRIN1 represent the linear combination of the responses that represents the greatest amount of variation (30.6 percent for production responses, 24.9 percent for purchasing responses). OJPRIN1 weights most heavily the contractor's efforts to develop a pull production control system, make workers responsible for quality, improve the plant layout, reduce setup times, and incorporate Group Technology. It also factors in efforts to improve equipment, stop production when defective conditions are detected, involve workers in preventive maintenance, and negotiating linear contract schedules. PJPRIN1 weights most heavily the contractor's efforts to reduce receiving requirements, help suppliers incorporate JIT into their own operations, reduce the vendor base to include only the very best suppliers, and achieve JIT supplier deliveries. It weighs single sourcing with a moderate, but negative, weight.

Table 13

Descriptive Statistics for Overall Implementation of JIT Production and Purchasing

Response:	PRODJIT Frequency	PRODJIT Percent	PURJIT Frequency	PURJIT Percent
1. Not at all.	0	0.0	1	4.2
2. Very little.	1	2.5	3	12.5
3. Some.	6	15.0	5	20.8
4. Moderate.	7	17.5	11	45.8
5. Considerable.	24	60.0	3	12.5
6. Almost total.	2	5.0	1	4.2
7. Total.	0	0.0	0	0.0
TOTAL	40	100.0	24	100.0
MEAN	4.5		3.625	
STANDARD ERROR	0.1432		0.2317	

Extent of JIT Production Implementation

Multiple linear regressions on response variables PRODJIT and OJPRIN1 were conducted to determine how the contracting environment impacts JIT implementation in the production area. As before, both full and reduced regression models were used to test the following hypotheses:

> H1b:At least one of the variables serving as indicators of contract requirements uncertainty (PRENEG, POSTNEG) will be significantly and negatively related to the extent that JIT production is implemented.
>
> H2b:At least one of the variables serving as indicators of cost uncertainty (KTYPE, AMT) will be significantly and negatively related to the extent that JIT production is implemented.
>
> H3b:At least one of the variables serving as indicators of asset specificity (Q1, Q2, Q3, COMP) will be significantly related to the extent that JIT production is implemented. Quality Level (Q2, Q3) will be negatively related while competition (COMP) and Q1 will be positively related.
>
> H4b:At least one of the variables serving as indicators of commitment (PROGPAY, GPROP) will be significantly and negatively related to the extent that JIT production is implemented.

The results of the two regressions are summarized in Table 15.

Table 14

First Principal Components--Extent of JIT Implementation

Variable Definition	Eigenvector
Variable OJPRIN1:	
OJ1 Effective plant layout for material flow	0.3080
OJ2 Dedicated equipment	0.1095
OJ3 Group Technology	0.2768
OJ4 Use of Focused Factory concept	0.1552
OJ5 Flexible work force	0.1735
OJ6 Quality Circles/Small Group Improvement Activities	0.1837
OJ7 Statistical Process Control	0.1107
OJ8 Production line stoppage for defects	0.2352
OJ9 Workers responsible for quality/inspection	0.3588
OJ10 Aggressive preventive maintenance program	0.0432
OJ11 Equipment and process improvement	0.2571
OJ12 Operator involvement in preventive maintenance	0.2343
OJ13 Reduction of setup time	0.2969
OJ14 Reduction of lot sizes (batches)	0.1252
OJ15 "Pull" production control system	0.4076
OJ16 Reduction of Work-In-Process inventories	0.0950
OJ17 Linear, "Drum-Beat" production rate	0.1713
OJ18 Establishment of linear contract schedules	0.2337
OJ19 Challenging govt. policies not supportive of JIT	0.1842
OJ20 Reduction of administrative/paperwork requirements	0.1120
Proportion of Variation Explained	0.3058
Mean	0.0000
Minimum Value	-5.5614
Maximum Value	8.1682
Standard Error of Mean	0.6225
Variable PJPRIN1:	
PJ1 Supplier Total Quality Control	0.1125
PJ2 Supplier incorporation of JIT internally	0.5520
PJ3 Reduction of supplier base	-.0267
PJ4 Long-term supplier partnerships	0.3779
PJ5 Single sourcing of suppliers	-.2422
PJ6 Local/geographically close suppliers	0.0216
PJ7 Supplier JIT deliveries	0.4633
PJ8 Minimization of receiving requirements	0.5870
PJ9 Reduction of administrative/paperwork requirements	0.0581
Proportion of Variation Explained	0.2493
Mean	0.0000
Minimum Value	-4.2688
Maximum Value	3.5905
Standard Error of Mean	0.3905

Table 15

Regression Results for JIT Production Implementation
(Response Variables PRODJIT, OJPRIN1)

Model	PRODJIT (N=40)		OJPRIN1 (N=37)	
Full Model:	F VALUE	PROB>F	F VALUE	PROB>F
	3.779	0.0043	8.888	0.0001
	R-SQUARE	ADJ R-SQ	R-SQUARE	ADJ R-SQ
	.4526	.3328	.6821	.6053
Variable	PARAMETER ESTIMATE	PROB> |T|	PARAMETER ESTIMATE	PROB> |T|
INTERCEPT	4.6561	0.0001	-1.7731	0.2216
POSTNEG	-0.3337	0.0008	-0.3778	0.2084
KTYPE	0.1169	0.7616	6.6244	0.0001
AMT	0.0011	0.1045	0.0070	0.0061
Q3	0.6592	0.0953	1.1036	0.3817
COMP	-0.0307	0.5068	-0.0837	0.5799
GPROP	-0.0029	0.6026	-0.0498	0.0115
JTIME	0.0222	0.0101	0.0842	0.0049
Reduced Model	F VALUE	PROB>F	F VALUE	PROB>F
	14.020	0.0001	18.806	0.0001
	R-SQUARE	ADJ R-SQ	R-SQUARE	ADJ R-SQ
	.5388	.5004	.7016	.6642
VARIABLE:	PARAMETER ESTIMATE	PROB> |T|	PARAMETER ESTIMATE	PROB> |T|
INTERCEPT	4.1222	0.0001	0.7728	0.4867
PRENEG	0.2538	0.0002		
POSTNEG	-0.3360	0.0001		
KTYPE			7.7626	0.0001
Q2			-5.1377	0.0004
PROGPAY			-3.5947	0.0013
JTIME	0.0195	0.0052	0.0583	0.0288

All hypotheses receive some support from the two regressions. However, the support is not consistent across both regressions. The only variable that is consistently significant in these regressions is JTIME, a control for the time that JIT has been implemented. It appears

as a significant variable in the full and reduced models of both regressions. We would expect the extent of JIT implementation to increase with increased JIT experience.

Hypothesis H1b receives quite strong, but somewhat mixed, support from the regression on PRODJIT. The variable POSTNEG is the most significant variable in both the full and reduced models with p-values of .0008 and .0001 respectively. Its regression coefficient is negative which supports H1b. In addition, it is joined by PRENEG ($p = .0002$) in the reduced model. However, its sign is not as expected so it provides mixed support. This regression suggests that JIT implementation is negatively impacted by difficult postaward changes and negotiations but receives a positive effect from difficult negotiations prior to contract award, at least in terms of the repondents' overall assessments of JIT production implementation. However, it should be noted that the model is not that good in terms of the amount of variation explained, about 33 percent (adjusted R-Square) for the full model and 50 percent for the reduced model. Given that caveat, the regression provides fairly strong, although mixed support for H1b. Hypothesis H2b receives strong, but mixed, support from the regression on OJPRIN1. KTYPE is the most significant variable ($p < .0001$) in both full and reduced models, but its regression coefficient is positive instead of the negative that was hypothesized. Contract amount was a significant variable ($p = .0061$) in the full model but did not appear in the reduced model. Its sign is also positive and suggests that the size of the contract as positively associated with the extent of JIT implementation. It was hypothesized that larger awards would be accompanied by increased controls which would negatively impact JIT. This supports the significance of cost uncertainty but not the hypothesized impact. Thus, the data provides mixed, but strong support for H2b.

Hypothesis H3b receives only questionable support from the reduced model for OJPRIN1. None of the variables representing asset specificity were significant in the full model, although Q2 was brought into the reduced model. Its sign is negative as hypothesized, providing some support for H3b. However, that suggests that intermediate levels of government quality requirements have a more negative impact on JIT production than the

highest level. That does not make much sense and therefore provides only questionable support for H3b.

H4b is supported by this regression (OJPRIN1). Government Property (GPROP) is a significant variable (p =.0115) in the full regression and has a negative impact on JIT production. In the reduced model, progress payments (PROGPAY) takes its place (p = .0013) and it also has a negative impact on JIT production. Thus in terms of commitment, as contractors rely on the use of government property or progress payments, related controls cause a negative impact on JIT production.

Extent of JIT Purchasing Implementation

Regressions conducted on the response variables PURJIT and PJPRIN1 test the impact of the contracting environment on the implementation of JIT purchasing. The following hypotheses are examined here:

H1d: At least one of the variables serving as indicators of contract requirements uncertainty (PRENEG, POSTNEG) will be significantly and negatively related to the extent that JIT purchasing is implemented.

H2d: At least one of the variables serving as indicators of cost uncertainty (KTYPE, AMT) will be significantly and negatively related to the extent that JIT purchasing is implemented.

H3d: At least one of the variables serving as indicators of asset specificity (Q1, Q2, Q3, COMP) will be significantly related to the extent that JIT purchasing is implemented. Quality Levels Q1 and Q2 will be negatively related while competition (COMP) and Q1 will be positively related.

H4d: At least one of the variables serving as indicators of commitment (PROGPAY, GPROP) will be significantly and negatively related to the extent that JIT purchasing is implemented.

The regression results are summarized in Table 16.

The first thing that must be noted is that the full models are not significant. At a significance level of .10 the overall statistical hypotheses that the regression coefficients of each model are equal to zero cannot be rejected. Thus, none of the hypotheses receive support from the full regressions.

Table 16

Regression Results for JIT Purchasing Implementation
(Response Variables PURJIT, PJPRIN1)

MODEL:	PURJIT (N=24)		PJPRIN1 (N=22)	
FULL MODEL:	F VALUE	PROB>F	F VALUE	PROB>F
OVERALL MODEL	1.753	0.1668	1.236	0.3402
	R-SQUARE	ADJ R-SQ	R-SQUARE	ADJ R-SQ
	.4340	.1864	.3510	.0670
VARIABLE:	PARAMETER ESTIMATE	PROB>|T|	PARAMETER ESTIMATE	PROB>|T|
INTERCEPT	2.9570	0.0010	-1.3350	0.3317
POSTNEG	0.0104	0.9425	0.1482	0.5733
KTYPE	0.7023	0.3581	1.0084	0.4626
AMT	-0.0011	0.4981	0.0027	0.3828
Q3	-1.1218	0.0984	-1.7310	0.1531
COMP	0.0868	0.2633	0.1191	0.3914
GPROP	0.0234	0.0389	0.0264	0.1792
JTIME	0.0323	0.0148	0.0329	0.1424
REDUCED MODEL:	F VALUE	PROB>F	F VALUE	PROB>F
OVERALL MODEL	4.135	0.0542	4.524	0.0232
	R-SQUARE	ADJ R-SQ	R-SQUARE	ADJ R-SQ
	.1582	.1200	.3011	.2346
VARIABLE:	PARAMETER ESTIMATE	PROB>|T|	PARAMETER ESTIMATE	PROB>|T|
INTERCEPT	4.2500	0.0001	0.7309	0.2504
AMT			0.0040	0.0594
PROGPAY	-.9375	0.0542	-1.7075	0.0285

The reduced models provide a little insight into the impact of the contractual environment on JIT purchasing efforts. The variable PROGPAY emerged as the most significant variable in both reduced models (actually, it is the only variable in the PURJIT model). Its negative sign supports hypothesis H4d, suggesting that as contractors depend on

progress payments rather than provide their own financing, the implementation of JIT purchasing suffers. AMT appears as the second variable in the PJPRIN1 reduced model, however a bonferroni approach with two variables and an overall significance level of .10 would indicate that it is not statistically significant. Its sign is not as hypothesized, suggesting that cost uncertainty in the form of the size of the contract, has a somewhat positive effect on JIT purchasing. These observations must be tempered by the fact that while the reduced models are significant at a .10 level, they explain less than 15 percent of the variation. Thus, weak, but consistent, support is shown for H4d. Weak and mixed support is shown for H2d. The others receive no support at all.

Discussion

Overall, the regressions using principal components produced much better models than those where the response variable involved an overall assessment by the person interviewed. The models enjoyed better significance levels and explained much more of the variation, as measured by adjusted R-Square values. In addition, production regression models tended to be much stronger than purchasing ones. With only one exception, production regressions had lower observed significance levels and higher adjusted R-Square values. One factor that may have caused this is the fewer number of purchasing observations. In addition, not all of the purchasing areas were implementing JIT whereas all production observations had implemented it. It is also possible that the characteristics of individual contracts is a much more important factor for production than for purchasing. In most of the observations, production tended to be organized along product lines and production runs were often contract specific. Purchasing, on the other hand, was usually centralized, with buyers organized along commodity lines rather than along product lines. Finally, purchasing is impacted by contract flow-down provisions plus FAR and other regulations governing the purchasing process as a whole, which are not contract specific.

None of the hypotheses proved to hold across all regressions. Hypothesis H3 received the strongest support, having variables significant to some degree in four of the eight

regressions. Increases in asset specificity, usually as measured in terms of the quality level, were associated with increased perceptions of government control over production as well as negative impacts of government control mechanisms on JIT production and purchasing. Asset specificity was also negatively associated with the extent of implementation of JIT in the production area. It was not associated with JIT purchasing implementation at all. Hypothesis H4 also received support from four regressions but the level of support was not as strong. Commitment, usually measured by progress payment use, appeared in four of the reduced models. Progress payments were associated quite strongly and negatively with the extent of JIT production implementation. There was also some suggestion that progress payments were related to government control mechanisms having a negative impact on JIT purchasing. The extent of implementation of JIT purchasing was also somewhat negatively impacted.

Hypothesis H2 received mixed support. Variables representing cost uncertainty, usually contract type, were significant in three regressions. However, the relationship was opposite to that hypothesized. It was found to be associated with more positive assessments of the impact of government control mechanisms on JIT production. It was also related to increased implementation of both JIT production and purchasing. It was hypothesized that contract types other than firm-fixed-price would lead to greater government control. However, it appears that cost incentive mechanisms are a positive factor when JIT is concerned. That could be true for several reasons. First, cost sharing arrangements provide an incentive to reduce costs and therefore an incentive to implement JIT. An incentive contract also provides a mechanism to make changes and reduce costs, without fear of being accused of defective pricing, by making the government a partner to such efforts. This suggests that contract type may reflect an appropriate governance structure that is suitable to the cost uncertainty inherent in the contract. It also may be that cost pressure overshadows the effects of government control mechanisms.

Hypothesis H3 received support in only two regressions. Contract uncertainty, primarily measured by the extent of postaward negotiations required to make contract

changes, was related to a negative impact of government controls on JIT purchasing. It was also negatively related to the extent to which JIT was implemented in the production area. Difficult postaward negotiations indicate considerable changes are occurring and the contractual resolution of them is very difficult. Such changes appear to directly impact JIT production activities but do not impact the extent to which JIT purchasing is undertaken. Further, more extensive negotiation efforts prior to contract award were positively related to the extent of JIT production, exactly opposite to that predicted. One possible reason for this is that tough negotiations lead to cost reduction pressures that prompt incentives for JIT. Such negotiations also delay contract award and shorten the time available to meet government need dates. That might cause schedule pressures that prompt cycle time reduction efforts. Extensive negotiations may also serve as an indicator of program importance and thus offer greater payback opportunities for JIT efforts.

In terms of the contracting environment, asset specificity appears to be the most important determinant of the level and impact that government control mechanisms have on the contractor's production and purchasing operations. Contract uncertainty also plays a role in the impact that those controls have on Purchasing. Concerning JIT implementation, contract uncertainty, cost uncertainty, asset specificity, and credible commitment all play a role in the implementation of JIT production. Cost uncertainty and credible commitment impact JIT purchasing implementation. However, the roles of contract and cost uncertainty are not necessarily as hypothesized.

Research Question 2

The second research question explores linkages between government contracting practices and JIT production and purchasing activities. This research question is exploratory in nature and no hypotheses were developed. However, the following questions were addressed:

R2a: Do government contracting policies, practices, and requirements have a greater impact on JIT purchasing activities than JIT production activities?

R2b: What relationships are there between contracting policies, practices, and requirements and JIT production activities?

R2c: What relationships are there between contracting policies, practices, and requirements and JIT purchasing activities?

Each of these research questions is addressed in turn.

Production and Purchasing Compared

Research question R2a asks whether JIT production and purchasing efforts differ with respect to the impact of government contracting practices. The regressions previously analyzed suggested that contract specific characteristics are more significant in explaining variations in the extent of JIT production activities conducted than that for JIT purchasing. That is not to suggest that purchasing faces fewer controls or that their impact is less severe. Many of the controls purchasing faces are more generic in nature rather than contract specific.

In order to determine whether government control mechanisms have a greater impact on JIT purchasing than JIT production efforts, purchasing and production responses were compared for all common questions and tests conducted to determine whether the mean responses were significantly different. Three tests were conducted using SPSS/PC+, the pooled-variance t-test, the separate-variance t-test, and the Mann-Whitney test. To be conservative, the highest p-value of the three was selected. The results of these tests are summarized in Table 17. Complete test results can be found in Appendix B.

In terms of an overall assessment of the level of government control over the internal operations of the firm, purchasing respondents generally assessed their operations to be under more government control than did production respondents (a mean of 5.083 compared to 4.55). The mean responses were significant at the .039 level. That does not assess the impact of those controls on JIT, but does indicate that, insofar as perceptions are concerned, purchasing is subject to a greater level of government control.

The responses assessing the impact of the 19 contracting practices suggest that JIT purchasing is less severely impacted than JIT production. Of the 19 variables, only three yielded purchasing responses that could be considered significantly different from production

Table 17

Comparative Assessments--Impact of Government Controls on JIT Production and JIT Purchasing

Variable Definition	Production Mean	Production Std Error	Purchasing Mean	Purchasing Std Error	P-Value*
Contracting Practices: (1=Strong positive effect, 7=Strong negative effect)					
G1 Govt. facilities/equipment	4.379	0.135	4.143	0.345	0.943
G2 Mil-Standards	5.077	0.181	4.500	0.282	0.093
G3 Govt. specification control	5.212	0.212	4.810	0.273	0.336
G4 Engineering change procedures	5.727	0.231	4.952	0.212	0.025
G5 Value Engineering Program	3.866	0.150	3.842	0.158	0.914
G6 Contract quality requirements	5.075	0.213	4.708	0.279	0.301
G7 Govt. QA Representative (QAR)	4.333	0.199	4.429	0.177	0.890
G8 Cost Accounting Standards (CAS)	4.425	0.199	4.167	0.143	0.438
G9 Reporting requirements	4.118	0.101	4.364	0.168	0.219
G10 Contract changes	4.487	0.146	4.454	0.194	0.936
G11 Progress payments/controls	4.188	0.198	3.667	0.229	0.105
G12 Socioeconomic programs	4.450	0.152	4.304	0.191	0.660
G13 Govt. subcontracting policy	4.667	0.177	4.818	0.268	0.640
G14 Govt. specified sources	4.654	0.200	4.600	0.349	0.895
G15 Disclosure of cost/pricing data	4.405	0.152	4.091	0.196	0.212
G16 Govt. audits/reviews	4.590	0.146	4.739	0.169	0.518
G17 Defense Priorities Systems	4.050	0.087	4.000	0.274	0.863
G18 Contract delivery requirements	4.025	0.162	4.083	0.312	0.869
G19 Govt. profit policy	4.150	0.146	4.167	0.130	0.938
CONTROL Overall assessment (1=No govt. control, 7=Total govt. control)	4.550	0.164	5.083	0.180	0.039
FREEDOM Overall assessment (1=Not restricted, 2=Completely restricted)	3.425	0.168	3.250	0.271	0.707

* P-Value represents the higher of the pooled variance T-Test, the separate variance T-Test, and the Mann-Whitney Test.

responses. Both purchasing and production responses judged the government's engineering change procedures to have a negative impact on JIT. The responses were significantly different at the .025 level with production responses being more negative. Similarly, Mil-Standards were judged by both to have a negative effect on JIT, but the difference in

responses was significant at only a .093 level. Even so, production appears to be impacted most. Finally, the mean responses for progress payments fall on each side of the value "4" which represented "no effect" with purchasing falling on the "positive" side. However, the difference in responses is only significant at the .105 level. Based on the evidence of these responses, JIT purchasing does not appear to be more restricted than JIT production by government contracting practices and regulations. This is also reflected in the respondents' assessment of the overall freedom they had to conduct JIT activities. The mean responses fall in between the values three and four ("somewhat restricted" to "moderately restricted"), with no statistical difference between them. This does not warrant the conclusion, however, that purchasing is not highly controlled by government regulation. Many of those interviewed carefully stressed in their comments that the controls are there and do have an impact on purchasing operations. However, for the most part, the respondents felt they could work within the regulations to achieve the desired ends of JIT purchasing.

JIT Production

Research question R2b seeks to determine how government contracting practices impact JIT activities. This research question was explored by examining responses to the closed-ended and open-ended questions relating to the impact of government controls on JIT and the relative freedom to conduct specific JIT production activities. In addition, indications will be given concerning the extent that JIT was implemented.

Impact of Contracting Practices

Table 18 compares anticipated impacts of the nineteen contracting practices on JIT production with the actual results. The contracting practice was judged to have a positive impact if the mean response was more than two standard deviations less than four. It was judged negative if two standard deviations above four. Otherwise it was given a zero for no impact. Table 19 gives a breakdown by response for each of the 19 government contracting variables. Each contracting practice will be discussed briefly in terms of its impact, as reflected in the two tables, and the explanations provided by the respondents. Appendix C

Table 18

Impact of Government Controls on JIT Production

Variable Definition	Expected Impact	Actual Impact
G1 Govt. property	-	-
G2 Mil-Standards	-	-
G3 Govt. specification control	-	-
G4 Engineering change procedures	-	-
G5 Value Engineering program	+	0
G6 Contract quality requirements	-	-
G7 Govt. QA Representative (QAR)	-	0
G8 Cost Accounting Standards (CAS)	-	-
G9 Reporting requirements	-	0
G10 Contract changes	-	-
G11 Progress payments	-	0
G12 Socioeconomic programs	0	-
G13 Govt. subcontracting policy	?	-
G14 Govt. specified sources	?	-
G15 Disclosure of cost/pricing data	-	-
G16 Govt. audits/reviews	-	-
G17 Defense Priorities Systems	?	0
G18 Contract delivery requirements	+	0
G19 Govt. profit policy	-	0

NOTE: Symbols are used as follows: "0" for no impact, "-" for a negative impact, "+" for positive impact, and "?" for unknown impact.

contains a summary of all positive and negative comments for each contracting practice. Only general observations will be provided here. To simplify discussion, the practices will be grouped into five categories, 1) government resources, 2) engineering and specifications, 3) internal controls, 4) contract negotiation issues, and 5) material and sourcing policies.

Use of Government Resources

The government frequently provides government owned property and progress payments to contractors. The research suggests the use of government property has a negative impact on JIT efforts. However, it does not appear to be a major problem since most respondents judged it to be not applicable or having no impact. On the positive side, it provides the contractor with dedicated equipment. On the negative side, contractors report

Table 19

Summary of Responses--Impact of Government Controls on JIT Production

Variable Definition	Response (%)							
	0	1	2	3	4	5	6	7
G1 Govt. property	27.5			5.0	40.0	22.5	5.0	
G2 Mil-Standards	2.5			10.0	17.5	35.0	25.0	10.0
G3 Specification controls	17.5			2.5	30.0	12.5	22.5	15.0
G4 Eng. change proc.	17.5	2.5			10.0	17.5	25.0	27.5
G5 Value Engineering	25.0		7.5	5.0	55.0	5.0	2.5	
G6 Quality reqts.		2.5	2.5	2.5	22.5	32.5	22.5	15.0
G7 Govt. QA Rep.	2.5	2.5	5.0	15.0	27.5	30.0	17.5	
G8 Cost Accounting Stds.		2.5	5.0	2.5	55.0	12.5	17.5	5.0
G9 Reporting reqts.	15.0			7.5	62.5	12.5	2.5	
G10 Contract changes	2.5			2.5	65.0	15.0	10.0	5.0
G11 Progress payments	20.0		5.0	7.5	50.0	7.5	5.0	5.0
G12 Socioeconomic progs.				7.5	60.0	17.5	10.0	5.0
G13 Subcontracting policy	2.5			5.0	55.0	15.0	12.5	10.0
G14 Govt. specified sources	35.0		2.5		30.0	20.0	10.0	2.5
G15 Cost/pricing data	7.5				75.0	5.0	5.0	7.5
G16 Govt. audits/reviews	2.5				60.0	25.0	5.0	7.5
G17 DOD Priorities Systems				7.5	85.0	2.5	5.0	
G18 Delivery requirements		2.5	5.0	10.0	62.5	10.0	10.0	
G19 Profit policy			5.0	7.5	65.0	15.0	5.0	2.5

NOTE: Responses are scaled as follows:
0=Not applicable, 1=Strong positive effect ... 4= No effect ... 7= Strong negative effect.

that its use is severely restricted so that it cannot be efficiently used and is so tightly controlled that contractors cannot improve the equipment. The dedication of resources fits nicely with JIT but limitations on making improvements or having the flexibility to use it to its best advantage inhibits JIT continuous improvement efforts.

Progress payments were generally judged to not impact JIT. It was anticipated that it would have a negative effect. Half the respondents scored it as not having any effect on JIT. Some cited financial and schedule advantages as positive impacts on JIT. Most of the negative assessments suggested progress payments prompt bad inventory decisions and restrictive inventory controls. The regression results pointed to progress payments as being

negatively related to the extent of JIT implementation so these results are unexpected and contradictory. Apparently, most respondents do not view them negatively, but contractors using progress payments did not make as extensive use of JIT as those who did not.

Engineering and Specification Controls

The government exerts considerable control over product and process specifications through the use of military standards, direct control over specifications, engineering change procedures, and its value engineering program. The respondents judged the first three to have a negative impact on JIT, as expected. The VE program was judged to have no impact when it should contribute positively, providing the mechanism for making the types of changes JIT encourages. However, a lengthy, cumbersome process discourages its use. Even those who had positive experiences said it was beneficial only during the early stages of the program. The difficulty associated with changing specifications characterize this and other areas of government specification controls.

Mil-Standards were applicable to all but one project. A few suggested such specs improved quality, provided desired information, and generally made things easier. However, most observations (70 percent) reported negative impacts. The major problem centered around quality requirements and inspection criteria. The major issues were in-process inspections with lot sampling plans and the use of visual inspection criteria which cause rejections for problems that are purely cosmetic, whose repair can lead to lower, instead of higher, reliability. Contractors also complained that the mil-standards are so restrictive that they cannot solve problems. Complicating the problem, they bind contractors to what they feel is outdated technology and methods. This strikes at the heart of JIT, which strives for continual improvement. One example reported by several respondents was MIL-STD-1567A, which deals with work measurement systems. One manager discussed the dilemma as follows:

> Colonel [deleted] ...has been pressing MIL-STD-1567A, pressing variance analysis. General [deleted] is telling him you've got to make this stuff good enough so we can use it for pricing evaluation, and so on. In the meantime, we're telling our IEs, you've got to get off this 1567, it's not productive, get on to changing your method. Get on to JIT, and those things, because we can save a fortune. So there's kind of a conflict there. If we were to go to one of these operations and say, we want you to have a large

> percentage of your standards within the accuracy constraints of 1567, use their variance analysis, and we want that always to be true, we have to give up the idea of moving to JIT because we're going to be changing things so rapidly that you'd have to have a large group of IEs following behind trying to keep the standards up to date all the time.

Compliance with mil-standards while at the same time pursuing the JIT goal of continual improvement is a dilemma that contractors must deal with.

Government control over specifications also had a negative impact. Seventy percent gave it negative ratings because it inhibits cycle time reduction and limits continuous improvement efforts. The major problem appears to be the limited flexibility contractors have to make changes and solve problems. In some cases, contractors reported they were subject to a "no change" policy. However, most said that changes were possible but just very difficult and time consuming. Most also recognized the need for the government to exercise some control over specifications, the issue is the degree and extent of that control, as one manager observed,

> It's not unusual for the government to want to control all levels of the specification, and inasmuch as that controls configuration and so forth, that's a worthy and a worthwhile idea. But, the changes become very difficult, because it increases your approval cycles and things on all documents associated with them. And so, if you can figure out how to do that efficiently, fine. If you can't, though, it causes your program to be more expensive. We need to find a technique to make those upgrades and so forth and preserve the integrity of it, and convince our customer that he doesn't need to control all the specs at all the levels.

Unfortunately, as the responses to this and the next question show, the procedures to make such changes are not very efficient, at least from the contrators' viewpoint.

Just as with the previous two areas of control, engineering change procedures had a negative impact on production's JIT efforts. One positive response resulted because the contractor had negotiated special change procedures to facilitate change. However, 70 percent of those interviewed were very frustrated in this area because the long approval process makes it extremely difficult to make changes. Many respondents stressed that the procedures to make changes were so time consuming and costly that they tended to discourage all but the most urgently needed changes or changes that have a very large and immediate payback.

The tight control the government exerts over specifications and the difficulty with which changes are made resulted in engineering change procedures, government control over specifications, and mil-standards to have, respectively, the three highest (most negative) mean scores of all contracting practices. This suggests the magnitude of the problem, in the contractors' view is very severe in terms of its impact on JIT production, especially the negative effect it has on continuous improvement efforts. In a similar vein, the government's control over quality is also problematical for JIT.

Controls over Quality

The government controls quality in two ways, 1) through various military standards and contract quality clauses, and 2) through quality assurance representatives (QAR) who ensure the contractor is in compliance. Contractual quality requirements were generally viewed as a negative factor for JIT. In fact, it received the fourth most negative rating. A few had positive experiences. One said the guidelines and tools were useful even at the expense of less flexibility. One reported the contract provided a $5 million incentive to improve reliability. Those, however, were the exceptions. Seventy percent had negative responses. The contractual quality requirements and JIT have congruent goals to improve quality. The conflict appears to be in the means used achieve that end. Contractors want to replace formal inspections with certified operators and statistical process control but feel constrained from doing so by requirements for government and company inspectors. Inspection points, especially if lot sampling is used, work against JIT's objectives of achieving continuous and linear flows of material. Contractors view some quality requirements as inadequate and nonproductive and do not feel free to achieve the highest level of quality possible.

The enforcer of the contract quality requirements is the QAR. It was anticipated that the QAR would have a negative impact on JIT production efforts. However, the mean response indicated no impact. The responses varied considerably with half saying the QAR either had no effect or contributed positively. Some found the QAR to be a valuable

resource for identifying problems and providing interpretation and guidance. Those who had negative experiences gave a wide variety of reasons, the most common being inspection delays and insistence on batch sampling methods. Some found the QAR supportive of JIT, some not supportive. Some judged them competent, some incompetent. The reported experiences and rationales were so diverse, and even contradictory, that the impact of the QAR on JIT appears to be a function of the individuals involved, both government and contractor personnel.

The contract quality requirements tend to bind the contractor and limit the extent to which it can achieve total quality control, especially in terms of eliminating centralized inspection points and giving the full responsibility for quality to production. The QAR can serve as a resource that minimizes the impact of government quality requirements on JIT or can be an obstacle that magnifies the problem.

Internal Controls

The government also imposes controls on contractors to ensure their actions are in the best interest of the government. Such controls include Cost Accounting Standards, reporting requirements, and audits to ensure the contractor complies with all government requirements.

Cost Accounting Standards were expected to have a negative effect and the data bore that out somewhat, although more than half of the respondents reported no impact. Those that had negative experiences complained that the standards were too complex and outdated. Specifically, respondents suggested that CAS labor tracking requirements are too detailed for flexible workers whose activities could span a number of different operations, perhaps even different contracts, and include both direct and indirect labor activities. CAS may impose a constraint in terms of the degree of flexibility workers can achieve and still be able to charge their time appropriately in compliance with government requirements.

It was expected that reporting requirements would have a negative impact on JIT but that does not appear to be the case for production. Over 75 percent of the respondents said reporting requirements had no impact on JIT or were not applicable. Some of the programs

were subject to Cost/Schedule Control System Criteria, known as C-Spec, and a few suggested it was helpful. The negative responses add little insight other than questioning the value of the time and resources required to meet government requirements.

The impact of audits was much like that of Cost Accounting Standards. Sixty percent said they did not impact JIT production efforts. However, 37.5 percent reported a negative impact. They were seen as disruptive to throughput because workers and inspectors become overly cautious and further decreased productivity by taking people away from their normal duties. In addition, audits were sometimes seen as promoting negative attitudes and penalizing cost reduction efforts. No specific JIT activities were identified, other than lowering productivity.

In general, these internal controls appear to be nuisance factors. Most of the contractors have found ways to live with them as a cost of doing business. The dangers to JIT are possible limitations on developing a flexible work force and generally undesirable attitudes spawned by audits. The threat is to the motivation and will to conduct JIT activities, a problem that also surfaced in the next area.

Contract Negotiation Issues

Four of the contracting practices involve negotiation issues, namely the cost/pricing data, the government's profit policy, contract delivery requirements, and changes/modifications to the contract after contract award. Of these, two were judged to have a negative impact and two to have no impact at all on JIT production efforts.

The requirement to provide cost or pricing data appears to have only a minor negative impact on JIT production. Seventy-five percent of the respondents did not feel that it impacted JIT production at all. However, a few had negative views and no one reported positive experiences. The negative impact is two-fold. First, it lengthens the proposal cycle and increases costs because of the data requirements, which are costly to collect and hard to keep current. More serious is the impact on a contractor's incentive to conduct JIT activities. A few respondents felt that JIT increased the contractor's risks of a defective pricing claim

and audit. Cost savings due to JIT are hard to predict and therefore disclose. If substantial cost savings occur, they feared the customer would charge that the contractor deliberately failed to fully disclose all information available. The negative responses seemed to be rooted in fear that JIT cost savings might attract the government's attention in a negative way. One respondent believed that JIT cost savings had actually resulted in an audit. This is perhaps very significant in light of the many recent scandals and accusations that have occurred against improper labor charging, overhead abuses, and defective pricing of spare parts.

Profit policy was expected to have a negative impact on JIT because of the government's tendency to base profit rates on costs and the possibility of negotiating away a contractor's cost savings on future contracts. A few concurred in that view. However, most (65 percent) rated it as having no impact. A few saw low profit rates and fixed-price-incentive contracts as positive motivators for JIT. The others saw restricted profits as discouraging long-term capital investment/cost-reduction efforts, rewarding inefficiency, and placing the contractor at risk for defective pricing. The respondents recognized the fact that cost reductions resulting from JIT activities might benefit the contractor only for the short term, but felt that those are the rules of the game and that such efforts were required to be competitive and win future contracts. The mean score suggested no impact overall.

The overall impact of contract changes is negative but does not appear to be that significant. Sixty-five percent of those interviewed said they had no impact on JIT. Thirty percent had negative experiences with two major issues, 1) the government's cycle time for issuing modifications to cover changes was excessive and put the contractor at some risk, and 2) engineering changes tended to disrupt production and increase costs. Many of those who responded that contract changes had no effect on JIT suggested that JIT actually made such changes easier to handle.

The contract delivery schedule was expected to have a positive impact on JIT production because of its relative firm demand pattern. A few respondents concurred in that view. However, most respondents rated it as having no impact on JIT. Some found their

contract schedules to be supportive of JIT and others not conducive. The needs and flexibility of the government customer varies. Most had no problem.

Overall, the contracting requirements discussed here are not problematical for JIT implementation. Most respondents were committed to JIT even if the government negotiated away cost savings because it was the prudent business thing to do to remain competitive. Postaward contract changes appear to be disruptive in general, which agrees with the regression results.

Material and Sourcing Policy

The last area to be examined involves government policy concerning socioeconomic programs, subcontracting, control over sources, and priority of government orders. The first three were determined to adversely impact JIT production somewhat. The other, the Defense Materials System and Defense Priorities System was found almost universally to have no impact at all and will not be discussed further.

Socioeconomic programs were not expected to adversely impact JIT production but its overall rating was negative. However, it does not appear to be too severe of a problem. Sixty percent judged its impact as none. The major issues involve the use of small businesses and small and disadvantaged businesses. Some felt positive about using them, suggesting they were willing to provide the kind of service needed for JIT. However, others had negative experiences where they felt forced to use unreliable vendors and unable to develop long-term, efficient buyer-seller relationships. The major concerns focused on vendor related issues, especially in terms of the supplier's willingness and ability to deliver a quality product on time.

The government's subcontracting policy was found to negatively impact JIT, even though 55 percent rated it as having no impact at all. The negative responses concentrated on purchasing issues, suggesting government policies increase proposal/purchasing cycle time and inhibit development of close supplier relationships. The policies of concern involved government requirements to use multiple sources and competitive bidding. In

addition, concerns were expressed about the impact of government purchasing regulations on the quality of incoming parts. Some feared the low-bid philosophy made quality suffer and that using multiple sources caused variation in materials that put their system out of control. Those that had experienced problems felt quite strongly about it with 22.5 percent of the responses falling in the highest two categories.

Government directed sources or those on a qualified parts list also had a negative impact on JIT efforts. Apparently, some situations arise when the contractor is forced to use a qualified vendor that would ordinarily not be the first choice and this adversely impacts cycle time, costs, and vendor performance. When asked why they did not work with the problem vendors to make them more compatible with JIT, the response was usually that the volume of parts was so low that the contractor lacked leverage or influence to get the vendor to perform.

Government controls did not have as much impact on JIT production activities as anticipated. Other than the government's various controls over engineering and specifications and its quality requirements, most of the impacts were quite moderate and should provide contractors a significant amount of latitude to conduct JIT activities, which is discussed next.

JIT Production Activities

JIT production efforts were examined in terms of twenty JIT activities organized under the framework of the Heard model. The respondents provided two perspectives, an assessment of the freedom from government restriction with which the activities could be undertaken and the extent to which the contractor had actually undertaken them. The responses are summarized in Tables 22 and 23. The discussion here draws from those tables and comments provided by the respondents.

Structured Flow Paths

According to the respondents' assessments, contractors are generally quite free to establish structured flow paths for their products. Nearly 88 percent of the respondents said

Table 20

Summary of Responses--Relative Freedom to Conduct JIT Production Activities

Variable Definition	Response Frequency (%)							Response Mean
	1	2	3	4	5	6	7	
STRUCTURED FLOW PATHS								
OF1 Plant layout	87.5	2.5	7.5		2.5			1.28
OF2 Dedicated equipment	67.5	17.5	10.0	2.5	2.5			1.55
OF3 Group Technology	95.0	2.5	2.5					1.08
OF4 Focused Factory	87.5	7.5	5.0					1.18
PEOPLE LEVERAGE								
OF5 Flexible work force	65.0	15.0	12.5	2.5	5.0			1.68
OF6 Quality Circles	100.0							1.00
CONTINUOUS FLOWS								
OF7 Stat. Process Control	87.5	2.5	2.5	5.0	2.5			1.32
OF8 Stop line for defects	85.0	2.5	10.0	2.5				1.30
OF9 Worker resp. for quality	47.5	15.0	12.5	7.5		15.0	2.5	2.52
OF10 Preventive maint.	92.5	5.0		2.5				1.12
OF11 Process improvement	65.0	7.5	15.0	2.5		2.5	7.5	1.92
OF12 Operator prev. maint.	92.5	2.5	2.5				2.5	1.22
LINEAR OPERATION								
OF13 Setup time reduction	97.5		2.5					1.05
OF14 Lot size reduction	87.5	5.0	2.5	2.5	2.5			1.27
OF15 "Pull" system	92.5	2.5	5.0					1.12
OF16 WIP reduction	90.0		5.0	2.5		2.5		1.30
OF17 Linear production	85.0	5.0	5.0	2.5			2.5	1.38
CUSTOMER PARTNERSHIPS								
OF18 Linear schedules*	62.2	10.8	10.8	10.8	2.7		2.7	1.92
OF19 Removing constraints	22.5	12.5	15.0	12.5	17.5	15.0	5.0	3.55
OF20 Paperwork reduction	22.5	10.0	20.0	22.5	7.5	15.0	5.0	3.38

Note: Responses were scaled as follows:
(1=Not restricted, 2=A little restricted, ..., 6= Heavily restricted, 7=Completely restricted)

*Response had three missing observations.

there was no government restriction to improve the plant layout or establish focused factories and 95 percent felt such freedom to use group technology. The only restrictions mentioned in those areas were inspection requirements, which occasionally impacted layout and focused factory efforts, and OSHA/EPA requirements, which constrained parts of the plant layout.

Table 21

Summary of Responses--Extent of Implemen ıtion for JIT Production Activities

Variable Definition	Response Frequency (%)							Response Mean
	1	2	3	4	5	6	7	
STRUCTURED FLOW PATHS								
OJ1 Plant layout	5.0	12.5	7.5	10.0	42.2	17.5	5.0	4.45
OJ2 Dedicated equipment	2.5	5.0	12.5	15.0	42.5	17.5	5.0	4.70
OJ3 Group Technology	10.0	12.5	17.5	7.5	37.5	20.0	7.5	4.10
OJ4 Focused Factory	2.5	2.5	7.5	12.5	40.0	22.5	12.5	5.02
PEOPLE LEVERAGE								
OJ5 Flexible work force		7.5	10.0	22.5	40.0	15.0	5.0	4.60
OJ6 Quality Circles	2.5	10.0	15.0	15.0	45.0	17.5	10.0	4.95
CONTINUOUS FLOWS								
OJ7 Stat. Process Control	2.5	15.0	22.5	30.0	27.5	2.5		3.72
OJ8 Stop line for defects	10.0	10.0	7.5	22.5	30.0	7.5	12.5	4.25
OJ9 Worker resp. for quality	2.5	12.5	17.5	20.0	20.0	15.0	12.5	4.38
OJ10 Preventive maint.	7.5	2.5	17.5	22.5	25.0	15.0	10.0	4.40
OJ11 Process improvement	12.5	7.5	22.5	17.5	30.0	7.5	2.5	3.78
OJ12 Operator prev. maint.	10.0	22.5	17.5	12.5	12.5	20.0	5.0	3.75
LINEAR OPERATION								
OJ13 Setup time reduction	5.0	5.0	32.5	7.5	37.5	2.5	10.5	4.15
OJ14 Lot size reduction		5.0	7.5	7.5	55.0	17.5	7.5	4,95
OJ15 "Pull" system	15.0	10.0	20.0	10.0	27.5	10.0	7.5	3.85
OJ16 WIP reduction		10.0	7.5	22.5	42.5	17.5		4.50
OJ17 Linear production		10.0	20.0	10.0	37.5	20.0	2.5	4.45
CUSTOMER PARTNERSHIPS								
OJ18 Linear schedules*	16.2	8.1	5.4	24.3	18.9	16.2	10.8	4.14
OJ19 Removing constraints	50.0	15.0	10.0	12.5	12.5			2.22
OJ20 Paperwork reduction	7.5	32.5	27.5	15.0	17.5			3.02

Note: Responses were scaled as follows:
1=Not at all, 2=Very little, ... , 6= Almost total, 7=Total

*Response had three missing observations.

The mean scores suggest that contractors felt somewhat more restricted in the use of dedicated equipment to improve the flow of material, even though most (65 percent) said they were unrestricted. The restrictions were due primarily to restricte ' use of government equipment and lack of funding (both contractor and government). While there were a few

restrictions cited for this group of JIT activities, the general conclusion is that contractors are exceptionally free to create the flow paths they desire.

This freedom is reflected in the extent to which the contractors reported their JIT activity in this area. Most of the contractors (65 percent) indicated they had achieved an efficient layout and used dedicated equipment to a "considerable" or better extent. The lowest ratings applied to the use of group technology. In many cases, production lines and work stations were dedicated to a single product or to a natural family of products. These had the same results as group technology cells. The contractors rated themselves as highly focused factories. The focused factory mean scores were the highest of any JIT activity (5.02). Even those who rated themselves low in this area appeared to the researcher to be quite highly focused. This seems to be a natural situation for the defense contractors visited. All were focused in terms of the technology, processes, and products they produced. The defense contracting environment appears to be generally unrestrictive, and even conducive, to JIT activities in this area.

People Leverage

Overall, contractors' responses indicated they had considerable freedom from government restriction to conduct people leverage activities. There was unanimous agreement that quality circles, or other types of employee involvement activities, could be pursued without any government restriction. In fact, many observed that the government supports such efforts. However, efforts to cross train and improve the flexibility of workers did encounter some restrictions. Thirty-five percent of those interviewed reported they had encountered restriction. Contractors reported they would like to shift quality inspection and buy-off to the production workers but could not do so because of government quality requirements. Further restriction was caused by mil-spec certification requirements, which requires costly training to enable workers to perform certatin tasks and thus restricts the number of employees that can perform those tasks. A few contractors stated their biggest problem concerned union, not government, restrictions.

The respondents rated themselves fairly high in terms of their people leverage activities. The mean scores of 4.60 for flexible workers and 4.95 for the use of quality circles were respectively the fifth and second highest scores. Sixty percent rated their use of flexible workers as "considerable" or better, with over 72 percent saying the same for their use of quality circles, although few actually called them that. Several of the contractors mentioned they were working to restructure the compensation and promotion systems on the basis of the number of tasks the worker is certified to perform. Only one respondent said they were not using quality circles (or something similar) and only three had not undertaken some type of effort to improve the flexibility of their work force. Apparently, contractors are able to take advantage of the freedom they have in this area to develop the skills and ability of their people.

Continuous Flows

JIT activities to achieve a continuous flow are broken into two general areas. The first involves achieving total quality control (TQC) so that the flow of material is not impaired by defective parts. The second is total productive maintenance to ensure that the flow of materials is not impeded by unreliable equipment.

Total Quality Control. Contractors' efforts to achieve total quality control were met with varying levels of restrictions. They generally felt quite free to pursue statistical process control (SPC) with just over 87 percent judging themselves to be totally unrestricted. Those that did report restrictions gave two main reasons, 1) the government's quality guidelines (especially 100 percent inspection requirements) is not wholly compatible with SPC, and 2) SPC identified problems needing correction but they lacked the freedom to quickly make those changes. One contractor indicated they had located the source of recurring quality problems, but the solution required product redesign and the customer would not approve it. Apparently contractors are free to use SPC, they just can't take full advantage of it to reduce inspection requirements and in some cases may have to go through engineering change procedures to make the required changes.

Contractors also reported they were quite free to stop the production line when abnormal or defective conditions were detected. Eighty-five percent judged themselves to be unrestricted in this area. The only restrictions reported dealt with pressure to meet schedule which prompts them to work around the problem rather than letting the line stop. One individual said line stoppages sent up a red flag inviting customer involvement. In these cases, it does not appear that government requirements preclude such line stoppages. In fact, for serious problems, contractors reported the government requires the line to stop. It appears that fear of not meeting contractually binding schedules or attracting undesirable customer attention tends to make line stoppages a troublesome thing for some production people.

Making production workers responsible for quality was one of the JIT activities most severely restricted. Its mean score (2.52) is the third highest of all the JIT production activities. A little over half the respondents reported some degree of restriction in this area. Those who reported no restrictions were quick to point out that while they felt free to make workers responsible for producing a quality product and to inspect their own work, they could not eliminate duplicate inspections by quality inspectors (company and government). Forty-five percent of the respondents said the government's quality inspection and documentation requirements did not permit operators to inspect and buy off their own work. Others cited job descriptions or union restrictions as the primary restriction. Contractors can shift responsibility for quality to the workers, but cannot take full advantage of this in terms of eliminating further inspection by a separate quality function. Some managers said that until those inspections were eliminated, workers would not take full responsibility for quality, but would still depend on inspectors to catch their mistakes.

The extent to which TQC activities were implemented was quite varied. Most were just getting started with SPC and this is reflected by its mean score (3.7) which was the third lowest score. Only 30 percent judged their SPC activities to be "considerable" or better. Only one reported no activity. The respondents were generally optimistic about its role and felt the government supported its use. As contractors gain experience with SPC and can

provide evidence that they have complete control over their processes, the government may be more willing to reduce the inspection requirements and be more supportive of certified operators. In terms of stopping the production line to correct defective conditions, half of the respondents rated their efforts "considerable" or better, although 20 percent rated themselves as doing very little or nothing. Many of the respondents did not seem totally convinced that line stoppages were appropriate for anything other than severe quality problems. Contractors' efforts to shift responsibility for quality to production workers were quite spread out. Fifteen percent said they were doing little or nothing in that regards while slightly over 47 percent rated their efforts as considerable or better. Since contractors reported heavier restrictions in this area, they seem to have taken some toll on these efforts. Contractors expressed a lot of frustration that they could not do more to eliminate separate inspections in favor of certified operators, or at least change those inspections to function more as quality audits. The respondents that reported the greatest success in this area were those associated with commercial products and those with lower quality levels. Overall, there appears to be considerable freedom to conduct these TQC activities, however, government quality policies appear to limit, to some extent, the full benefits that contractors believe they could achieve.

Total Productive Maintenance. Contractors generally rated themselves as quite free to conduct activities in this area. More than 92 percent of the respondents said they were completely unrestricted to conduct preventive maintenance and involve production workers in routine preventive maintenance activities for the equipment they operate. In some cases, preventive maintenance activities were contractually required. A few encountered problems getting government funding for refurbishment and preventive maintenance of government property. Concerning operator preventive maintenance activities, the vast majority of the respondents felt that operators could be involved in routine preventive maintenance activities, recognizing that some activities required specialized skill or certification. It was in the area of improving equipment and processes that contractors felt most restricted. Its mean score indicated it was the fourth most restricted JIT activity. Thirty-five percent of the

respondents indicated they had encountered some form of government restriction, mostly due to controls over government property and lack of funding. This is an area in which government controls over specifications and government equipment can restrict the contractor's freedom to make process and equipment improvements. Overall, contractors appear free to carry out most preventive maintenance activities, including worker involvement, but are somewhat more restricted in improving equipment and processes.

In terms of implementation, contractors have made more extensive use of preventive maintenance than improving equipment/processes or involving workers in routine preventive maintenance, both of which have mean scores indicating they are among the five least used JIT activities. Half of the respondents rated their preventive maintenance activities as "considerable" or better, whereas 40 percent or less claimed that for equipment/process improvement efforts and operator involvement. It should be noted that most of the operations in these defense electronics firms were primarily labor intensive and thus provided less of an opportunity for preventive maintenance and equipment improvement activities. Contractors efforts in these areas focused on buying better quality tools, training workers to care for them and use them properly, and ensure that calibrations were conducted as needed. The frequencies and mean scores for these areas suggest that contractors evaluated themselves somewhat lower than the total quality control activities.

Linear Operation

Defense contractors are exceptionally free to undertake activities to make their internal production more linear. At least 85 percent of the respondents judged themselves to be totally free to reduce setup time, decrease lot sizes, establish a "pull" production control system, reduce work-in-process inventories, and institute linear production rates. The mean scores suggest that setup time reduction and establishment of a "pull" system are among the five activities with the least restriction. Government documentation was the main restriction cited for reducing lot sizes. As lot sizes decrease and the number of production runs increase, more sets of documentation must be kept. Batched lot acceptance tests also appear

to be problematical, forcing larger lot sizes than the contractor desires. Batch testing requirements also surfaced as a problem with WIP reduction as did progress payments. Documentation requirements was also cited as a problem for establishing a "pull" system. Efforts to achieve a linear production rate were restricted by nonlinear contract delivery schedules that could not be changed and inspection requirements. Overall, contractors were exceptionally free to conduct these JIT activities.

According to the mean responses, contractors made most extensive use of lot size reduction, followed by WIP reduction, establishment of a linear production rate, setup reduction, and creation of a "pull" system. Eighty percent rated their lot size reduction efforts as "considerable" or better. Sixty percent did the same for WIP reduction and establishment of linear production rates. Contractors also concentrated on reducing setup times, with 50 percent assessing their efforts as "considerable" or better and only 10 percent saying they did very little or none of it. In some cases, there was less opportunity for setup reduction because the lines were so dedicated that only one product was produced, leaving no need for changeovers. Most of the setup reduction activity concentrated on establishing dedicated work stations so that no setups would be required. Contractors had not made as much progress using a "pull" system. Twenty-five percent reported they were doing very little or nothing in this area. Contractors were trying numerous approaches with no two being exactly the same. Many used Kanban variations, such as Kanban squares, boxes, bins, and cards. Some were using MRP for documentation but were pulling from the production floor. One contractor had a sophisticated electronic floor control system with bar codes and wands which would not let a work station proceed until the demand pull was received. Some contractors were still operating in a push environment but were working toward becoming a true pull system.

According to their own assessments, contractors have been able to reduce lot sizes and WIP inventories and create linear production rates to permit the flow of material to move more quickly and smoothly through the system. The problems that have prevented some

from making more progress appears to be documentation requirements, batch lot acceptance tests, and the government's own demand requirements, as reflected in the contract schedule.

Dependable Demand-Customer Partnership

The last set of JIT production activities involves efforts to gain customer support to more effectively carry out the JIT improvement process. It is in this area that contractors have encountered the most restrictions and made the least progress. The mean responses for negotiating linear contract schedules, challenging and changing government constraints, and reducing documentation requirements indicated these were among the five most restricted activities.

The brightest area is the establishment of linear contract delivery schedules that are supportive of JIT. Sixty-two percent felt free to establish such schedules. In some cases, the customer cannot or will not make the contract schedule more linear and will not permit early or partial shipments. That can serve as a serious constraint to the contractor since the contract schedule drives the whole operation. Most of the contractors did not experience such severe restrictions and found the customer to be more cooperative. In terms of implementation, only 16 percent indicated they had not been able to negotiate more linear schedules. Nearly 46 percent claimed to have done so to a "considerable" or greater extent. The other two areas have the distinction of being rated, overall, the two most restricted activities and those with the lowest implementation.

Reducing administrative and documentation requirements was the second most restricted activity and the next to the last in terms of implementation. More than 77 percent of the respondents indicated there were some level of government restriction to reducing documentation requirements, citing that the government requires documentation and paper audit trails. In spite of the restrictions, only 7.5 percent said they had not made some attempt to reduce administrative and documentation requirements. Slightly over 12 percent reported they had done so to a "considerable" extent. Some contractors were working toward establishing a paperless system using electronic data interchange and storage. However, they

encountered resistance by auditors and contract administrators, who wanted paper documentation and would not accept microfiche, let alone electronic storage media. Contractors that reported successes in this area did so mainly with internal, company required documentation not required for audit purposes.

One of the fundamental tenets of the JIT philosophy is to never accept constraints but always try to improve. However, the mean scores suggest that challenging government constraints is the most severely restricted and the least implemented. Over 77 percent of the respondents rated challenging government constraints as being restricted, primarily because the customer is not responsive. A few said it is much easier to work around, rather than challenge government constraints. It is hard to say whether the problem involves unresponsive customers or nonchallenging contractors. A full 50 percent reported they had not tried to challenge government constraints and another 15 percent said they had done very little. Therefore, some of those who reported restrictions had very little, or no experience making such challenges. To be fair, in many cases JIT implementation was so new that there was plenty of improvement to make without going after government restrictions. Still, there appears an overall reluctance to challenge government constraints. The danger to JIT implementation, especially as it matures, is that some of those constraints may be successfully dealt with and some may not even be there. When asked whether government constraints were real or perceived, 40 percent said perceived, 35 percent answered real, 15 percent thought they were half of each, and 10 percent said they hadn't encountered any obstacles at all. That at least opens the door to the possibility that some of the obstacles are perceived and not real. If challenged or questioned, they would go away. The JIT philosophy requires such challenges to be made, and until contractors start doing so, their JIT production efforts will be limited by real or imaginary constraints.

This section has focused on JIT production efforts and the impact of government contracting practices on those efforts. The next section examines the impact of government contracting requirements on purchasing activities conducted to support JIT production.

JIT Purchasing

The objective of research question R2c is to determine how government contracting practices impact JIT purchasing. This section follows the same pattern of analysis used in the previous section to identify the linkages that exist between specific contracting practices and JIT purchasing activities.

Impact of Contracting Practices

Expectations concerning the impact of nineteen contracting practices and the actual impacts are summarized in Table 22. Just as with JIT production, the impact of contracting practices on JIT purchasing was much less than anticipated. The mean scores indicated that eleven of the nineteen had no impact overall. However, in some of those cases there were negative and positive ratings which canceled each other out, instead of a preponderance of no impact ratings. Eight practices were found to have overall negative impacts. Table 23 provides a breakdown by response for each contracting variable. Each will be discussed briefly in terms of its impact, as reflected in the tables and the rationale given by the respondents. They are grouped in the same manner as in the previous section. In some cases, the responses were similar to those by production. In such cases, that will be noted and the discussion abbreviated.

Use of Government Resources

The use of government property and progress payments were not major factors for purchasing. Government property did not even apply to nearly 42 percent of the observations. A few had positive experiences because it provided dedicated equipment and improved quality. Those who had negative experiences encountered long cycle times to get approval to use it, found such property to be late or defective, or were completely restricted from using it even though it was available.

Progress payments were expected to have a negative impact on JIT purchasing. A few responses supported that view, citing progress payments as encouraging inventories and demotivating JIT purchasing efforts. However, the overall rating was no impact and there

Table 22

Impact of Government Controls on JIT Purchasing

Variable Definition	Expected Impact	Actual Impact
G1 Govt. property	0	0
G2 Mil-Standards	-	0
G3 Govt. specification control	-	-
G4 Engineering change procedures	-	-
G5 Value Engineering program	+	0
G6 Contract quality requirements	-	-
G7 Govt. QA Representative (QAR)	?	-
G8 Cost Accounting Standards (CAS)	?	0
G9 Reporting requirements	-	-
G10 Contract changes	-	-
G11 Progress payments	-	0
G12 Socioeconomic programs	?	0
G13 Govt. subcontracting policy	-	-
G14 Govt. specified sources	-	0
G15 Disclosure of cost/pricing data	-	0
G16 Govt. audits/reviews	-	-
G17 Defense Priorities Systems	+	0
G18 Contract delivery requirements	?	0
G19 Govt. profit policy	-	0

NOTE: Symbols are used as follows: "0" for no impact, "-" for a negative impact, "+" for positive impact, and "?" for unknown impact. Actual impacts were determined by comparing mean scores, with those more than two standard deviations above/below four being rated negative and positive impacts respectively. The remaining were rated as no impact.

were actually more positive responses than negative responses. The positive responses centered on the benefits of providing progress payments to suppliers to get material flowing and having the government finance required inventories/early buys. The view that it helps finance inventories appears to be counter to JIT logic, although the respondents claimed they were not accumulating excessive inventories. Progress payments appear to be a two edged sword. Apparently, they can be used wisely to support JIT activities or serve as safety nets to inhibit JIT progress. As was the case with production, progress payments are not viewed negatively, although the regression results indicate they are related negatively to the extent of JIT purchasing.

Table 23

Summary of Responses--Impact of Government Controls on JIT Purchasing

Variable Definition	Response Frequency (%)							
	0	1	2	3	4	5	6	7
G1 Govt. property	41.7	4.2	4.2		25.0	20.8	4.2	
G2 Mil-Standards			4.2	25.0	20.8	25.0	16.7	8.3
G3 Specification controls	12.5		4.2	8.3	20.8	25.0	25.0	4.2
G4 Eng. change proc.	12.5				37.5	0.8	25.0	4.2
G5 Value Engineering	20.8		4.2	12.5	54.2	8.3		
G6 Quality reqts.		4.2	2.5	8.3	29.2	37.5	8.3	12.5
G7 Govt. QA Rep.	12.5			4.2	50.0	29.2		4.2
G8 Cost Accounting Stds.			4.2	4.2	62.5	29.2		
G9 Reporting reqts.	4.3			4.3	60.9	26.1		4.3
G10 Contract changes	8.3			4.2	58.3	16.7	8.3	4.2
G11 Progress payments	25.0		8.3	20.8	37.5	4.2	4.2	
G12 Socioeconomic progs.	4.2	4.2		20.8	33.3	20.8	8.3	8.3
G13 Subcontracting policy	4.3		4.3	4.3	34.8	21.7	21.7	8.7
G14 Govt. specified sources	37.5		4.2	4.2	25.0	16.7	4.2	8.3
G15 Cost/pricing data	8.3		4.2	8.3	66.7	12.5		
G16 Govt. audits/reviews	4.2				41.7	41.7	8.3	4.2
G17 DOD Priorities Systems	4.2	4.2	4.2	16.7	50.0	12.5		8.3
G18 Delivery requirements		8.3	8.3	4.2	45.8	20.8	4.2	8.3
G19 Profit policy					91.7	4.2		4.2

NOTE: Responses are scaled as follows:
0=Not applicable, 1=Strong positive effect, ... ,4= No effect ... 7= Strong negative effect.

Engineering and Specification Controls

Mil-standards were expected to have a negative impact on JIT purchasing but its overall mean score did not support that conclusion. The responses were quite varied. Some rated them positively because they provide standardization or improve quality. Negative ratings found mil-standards increase lead time, limits the availability of suppliers, and creates interpretation problems. Mil-standards are a mixed blessing for purchasing and do not have the severe impact that production encounters.

Government controls over specifications and associated engineering change procedures have a fairly strong negative impact on JIT purchasing, just as it did for JIT

production. Over 54 percent of the assessments concerning the impact of government control over specifications were negative. Engineering change procedures had the most negative overall rating than any other contracting practice, as was the case for production. There were no positive responses. All the negative responses cited the lengthy, difficult process associated with engineering changes. Not only does it discourage change, it also causes a corresponding increase in the purchasing cycle when such changes are required by the vendor. In some cases, the contractor appears to be in a no-win situation. JIT stresses continuous improvement which thrives on change. Yet the change process that contractors must deal with is so cumbersome that using it causes its own set of disruptions, especially for purchasing which must deal with engineering changes imposed by the government, those brought about internally, and those required by its vendors.

Value engineering should have been a positive tool for purchasing. However, just as in the case with production, it is little used. Of those who provided positive ratings, only two had actually used it to reduce costs. The others said it will be used in the future. The major problem is the cumbersome procedures and long approval time, responses that mirror those of production.

Controls over Quality

Purchasing respondents rated contractual quality requirements and the government quality assurance representative (QAR) as negatively impacting JIT activities. The purchasing responses do not focus on quality issues so much as how contract quality requirements make the purchasing process more difficult. The major objections were that the requirements are not cost effective and cause interpretation problems. In contrast, a few respondents indicated contractual quality requirements helped improve the quality of the purchased parts. The responses suggest there are problems but there is no consistency in terms of its impact on JIT purchasing.

The government QAR has an overall negative impact on JIT purchasing, although it does not appear to be too severe. About a third of the respondents reported negative

experiences centered around delays in inspection and resolving the disposition of material requiring material review boards. The responsiveness of the QAR in terms of timeliness appears to be the biggest issue for purchasing.

Internal Controls

With the exception of Cost Accounting Standards, internal controls had a negative impact on purchasing. Over 60 percent of the respondents judged CAS to have no impact. Documentation and compliance issues cause a few problems, as do restrictions on interdivisional transfers. However, CAS does not appear to be as significant a problem for JIT purchasing as it was for JIT production.

Reporting requirements are somewhat more of a problem, even though 60 percent of the respondents suggested they had no impact on JIT purchasing efforts. Thirty percent provided negative ratings based on the time and costs of preparing the reports that could be spent in more productive uses. One suggested that the very fact they had to report on the number of single sources used discourages the use of single sourcing. This is the only JIT purchasing activity mentioned as being impacted.

Audits and reviews were judged to have a more severe impact on JIT purchasing. Over half of the respondents rated it negatively. Occasionally, prolonged audits delay contract award and program start-up, causing more work for purchasing because quotes expire and purchasing lead time is reduced (because need dates rarely change). Audits also drain purchasing's resources (personnel and time) which reduces productivity. Audits are also accused of prompting unhealthy attitudes of paranoia and distrust. Audits were rated more negatively by purchasing than production, possibly because it is saddled with exceptionally heavy documentation requirements. Although there were no positive experiences, many respondents recognized they were necessary to some degree. However, most were overwhelmed by the frequency and extent of the audits, such that one would be underway almost constantly. One respondent said the problem becomes so great that people become gun shy and start focusing on the paperwork more than getting the job done.

Contract Negotiation Issues

Of the contracting practices associated with negotiations, all but contract changes and modifications were assessed as having no impact on JIT purchasing. Providing cost or pricing data does not appear to impact JIT purchasing. The purchasing respondents generally felt it was part of doing business. Further, purchasing uses it to get information from its vendors and is therefore much more tolerant. Contract delivery schedules have no impact on JIT purchasing according to over 45 percent of the respondents. However a third of them had negative experiences, all of them citing unrealistic schedules with inadequate purchasing lead time. On the positive side, 20 percent said the contract provided a good schedule for ordering. Profit policy was expected to have a negative impact on JIT purchasing activities but 91.7 percent said it had no impact. The government's preaward negotiation activities do not appear to impact JIT purchasing, insofar as these assessments indicate.

Postaward negotiation activities impact JIT purchasing somewhat more. Most respondents (58.3 percent) encountered no impact due to contract changes. However, nearly thirty percent had negative experiences. Each reported a unique experience, such as quantity changes, engineering revision changes, schedule accelerations, and mil-specification changes. They found the changes to be disruptive to suppliers and frequently did not provide enough lead time to deal with the problems. In some cases, they indicated they lacked the ability to determine if the changes were government caused or contractor caused. The responses did not point to an overriding problem or issue concerning JIT purchasing activities.

Material and Sourcing Policies

One would expect that policies dealing with sourcing issues would impact JIT. However, only subcontracting policy was shown to have an overall negative impact on JIT purchasing. The others were scored overall as no impact because positive and negative assessments cancelled each other out.

Socioeconomic programs had a diversity of impact on JIT programs. A third of the respondents indicated no impact, while just over a third gave negative ratings and just under

a third positive ratings. The main issue is the use of small and disadvantaged businesses. The respondents explained that there are not enough such business with the technological skills to be defense electronics suppliers. However, those that reported positive experiences found small businesses and small and disadvantaged businesses to be good producers and willing to support JIT efforts. Apparently some are complying to good advantage and some are not. This area received an overall negative rating by production respondents who cited the impact on purchasing and the forced use of unreliable vendors. That is not supported as strongly by the purchasing respondents. Since production is directly impacted by a vendor's failure to perform, especially in a JIT environment, one would have to give serious consideration to their evaluation and consider socioeconomic programs to be at least a potential problem for JIT purchasing.

Over half of the respondents judged the government's subcontracting policy to have a negative impact on JIT. Requirements for multiple sourcing/competitive bidding were cited most often as restricting the development of close relationships with one best source. Others suggested the government's rules increased the purchasing cycle and procurement costs, caused disagreements with contract administration personnel, and forced actions that the contractor did not consider good business practices. It is encouraging that over a third of the respondents felt that the subcontracting policy did not impact their JIT eff .s. Apparently some of the contractors have found ways to pursue JIT to some degree within the confines of government requirements.

The overall rating for government specified sources was no impact. However, 29.2 percent reported negative experiences. Most cited problems with qualified parts list suppliers, who operate under heavy schedules and who cannot, or will not, provide the desired performance, in terms of quality and delivery. Others indicated that directed sources locked the contractor into obsolete technology and nonstandard parts. A few suggested qualified parts lists greatly simplify source selection, as long as the sources are good performers. It does not appear to be too big of a problem since 62.5 percent of the

purchasing respondents (65 percent of the production respondents) reported specified sources either have no impact or are not applicable.

The Defense Materials System/Defense Priorities System generally had no impact on JIT purchasing. The program is designed to help defense contractors get parts and materials quickly and it was expected that it would have a positive impact on JIT purchasing. However, it does not appear to have much impact overall. Six respondents reported benefits of improved supplier deliveries and three reported the opposite due to low ratings. Half said it had no impact whatsoever.

This section has focused on the impact of government contracting practices on JIT purchasing. In general, JIT purchasing was impacted much less than anticipated. Part of that was due to a diversity of views, some positive and some negative, concerning the impact of many contracting issues. In addition, there was a wide difference in JIT experience, with 20.8 percent claiming no experience and 12.5 percent having less than a year. However, 58.5 percent claimed to have over two years experience with JIT purchasing. Such a variation in experience may have contributed to the wide variation in responses. Whatever the cause, the analysis of the open ended questions uncovered some interesting individual observations but few commonly shared experiences. This suggests that defense contractors should have considerable freedom to conduct JIT activities, which is discussed next.

JIT Purchasing Activities

JIT purchasing activities were examined in terms of nine activities. Each respondent provided two perspectives as to their JIT efforts, an assessment of the relative freedom (from government restriction) with which the activity could be undertaken, and the extent to which they had actually been undertaken. The responses are summarized in Tables 24 and 25. These, plus the explanations provided by each respondent, will form the basis for the discussion at hand.

Table 24

Summary of Responses--Relative Freedom to Conduct JIT Purchasing Activities

Variable Definition	Response Frequency (%)							Response Mean
	1	2	3	4	5	6	7	
PF1 Supplier TQC	91.7	8.3						1.08
PF2 Supplier JIT production	91.7		4.2		4.2			1.25
PF3 Suppler base reduction	50.0	25.0	20.8			4.2		1.88
PF4 Supplier partnerships	58.3	12.5	12.5	4.2	4.2	8.3		2.08
PF5 Single sourcing	25.0	16.7	20.8	8.3	16.7	4.2	8.3	3.21
PF6 Local suppliers	70.8	16.7		4.2		8.2		1.71
PF7 JIT deliveries	83.3	4.2	4.2		8.3			1.46
PF8 Streamline receiving	25.0	12.5	25.0	8.3	12.5	16.7		3.21
PF9 Paperwork reduction	16.7	29.2	8.3	4.2	16.7	25.0		3.50

Note: Responses were scaled as follows:
(1=Not restricted, 2=A little restricted, . . ., 6= Heavily restricted, 7=Completely restricted)

Table 25

Summary of Responses--Extent of Implementation for JIT Purchasing Activities

Variable Definition	Response Frequency (%)							Response Mean
	1	2	3	4	5	6	7	
PJ1 Supplier TQC		8.3	4.2	12.5	70.8		4.2	4.62
PJ2 Supplier JIT operations	29.2	33.3	8.3	16.7	12.5			2.50
PJ3 Reduction of supplier base	4.2	4.2	12.5	20.8	58.3			4.25
PJ4 Supplier partnerships	4.2	4.2	12.5	25.0	45.8	8.3		4.29
PJ5 Single sourcing	8.3	37.5	29.2	20.8	4.2			3.00
PJ6 Local suppliers	8.3	16.7	1C.7	45.8	12.5			3.38
PJ7 Supplier JIT deliveries	4.2	29.2	20.8	25.0	16.7	4.2		3.33
PJ8 Minimal receiving reqts.	12.5	16.7	25.0	12.5	29.2	4.2		3.42
PJ9 Paperwork reduction	20.8	50.0	4.2	16.7	8.3			2.42

Note: Responses were scaled as follows:
(1=Not at all, 2=Very little, ... , 6= Almost total, 7=Total)

Supplier Total Quality Control

Purchasing has the greatest amount of freedom to help suppliers achieve total quality control and this activity was also the most extensively implemented. Over 90 percent of those interviewed indicated there were no government restrictions associated with helping suppliers improve their quality. The few who indicated they felt some restriction could not provide any examples. Seventy-five percent rated their implementation in this area as "considerable" or better and none indicated no activity.

Supplier JIT Production

Helping suppliers incorporate the JIT philosophy into their own operations ranked as the second least restricted activity. The vast majority (91.7 percent) of the respondents rated themselves as totally unrestricted in this area. However, that freedom did not translate into action, as it was one of the least implemented. Only 12.5 percent rated their implementation as "considerable" or better and 62.5 percent said they were doing it very little or not at all. One possible reason for this is that the contractors want to master JIT first, before exporting it. Another is that suppliers can also be competitors in the defense business. Some indicated low volumes do not provide the contractor with enough leverage to get suppliers' interested. Whatever the reason, this appears to be a little used tool. Contractors appear to be willing to work with suppliers on quality issues but not improving their overall operations with JIT.

Reduction of Supplier Base

Half of the respondents judged themselves completely free to reduce the vendor base to include only the very best suppliers. The other half felt restricted, mostly by multiple sourcing/competitive bidding requirements and the requirement to use government qualified suppliers (which are not necessarily the best suppliers). However, such restrictions do not appear to be too troublesome since this area was one of the top three JIT purchasing activities in terms of its mean implementation score (4.25). All contractors reported some efforts to reduce their supplier base and 58.3 percent rated their efforts as considerable. While they

must keep multiple sourcing, competitive bidding, and government approved sources in mind, contractors have pared their list of qualified vendors to some degree.

Supplier Partnerships

There also appear to be some limitations to the establishment of long-term contracts/partnerships with selected vendors. Nearly 42 percent of the respondents indicated there were some restrictions associated with this activity. The contractors' explanations suggest that government contracts tend to cover a year or less and are not conducive to long-term contracts with vendors unless the contractor wishes to assume a considerable amount of risk. Competitive bidding requirements and audit fears are perceived as prohibiting relationships from getting "too close." However, contractors have apparently found ways to develop closer relationships with suppliers. Only 4.2 percent indicated they had no such activities underway while 54.1 percent rated their efforts as "considerable" or better. Some of these relationships were the result of sole source situations or mature programs whose supplier relationships had naturally formed over time. However, some reported competing long-term requirements contracts or contracts with multiple options to highly qualified sources so that JIT partnerships could be formed. In such ways, contractors were able to meet competition requirements and still develop quasi-supplier partnership arrangements.

Single Sourcing

Single sourcing emerged as one of the most restricted JIT purchasing activities. Seventy-five percent of the respondents indicated restrictions applied to making the decision to single source. Government contracting requirements encourage multiple sourcing and competitive bidding as the preferred supplier relationship and provide disincentives to single source arrangements. Therefore it is no surprise that single sourcing was one of the least used JIT purchasing activities. However, the extent to which contractors are using it was somewhat surprising. One fourth of the respondents said they were using single sources to a "considerable" or better extent. Only 8.3 percent said they were not using single sources at all. In some cases, the single sources were actually sole source situations, but ones with

which the contractor felt comfortable. In other cases, the single sources were competitively selected to comply with government regulations. Most respondents indicated that rather than going strictly single source, they were dual sourcing. That met the requirements of multiple sourcing and competitive bidding but still limited the number of suppliers so that good working relationships could be developed.

Local Suppliers

Contractors generally felt free to develop local or geographically close suppliers. Just over 70 percent rated this activity as unrestricted. The rest indicated that directed sources or qualified parts lists precluded the development of local sources. Those source restrictions were sometimes due to the government, to the part design, or the technology involved. For example, contractors said they could locally source machined parts or castings but not most electronics parts. One contractor reported competitive bidding considerations restricted the use of local sources if they were not low bidder. Another indicated there were no government requirements that precluded local sources but that political considerations could be problematical. It chose to distribute its sources strategically to increase the chances of its program being funded by Congress. On the whole, contractors appeared to make only moderate use of local sources. Only 12.5 percent felt they could rate their use of local sources as considerable, 45.8 percent rated it as moderate. Most indicated they prefer to use local sources whenever they can, but frequently had little choice.

Supplier JIT Deliveries

This activity, like helping suppliers incorporate JIT into their own operations, is one of the least restricted but also one of the least used. Most of the contractors (83.3 percent) rated this activity as unrestricted. Those that encountered restrictions each had a unique reason. One said mil-spec houses have minimum buys and will not cooperate with JIT deliveries. Two said quality inspection requirements and associated documentation were not conducive to small lots. The inspection and documentation issue is important because it impacts not just the contractor, but the supplier and government contract administration

personnel as well. Contractors generally indicated that JIT deliveries could only be used on their most important and high dollar items. Only 20.9 percent rated their use of JIT deliveries as "considerable" or better. A third of the contractors were doing very little or nothing.

Minimal Receiving Requirements

Minimizing receiving requirements was one of the most restricted JIT purchasing activities. Seventy-five percent of the respondents encountered restrictions due to incoming inspection and documentation requirements. All but 12.5 percent of the contractors were taking some action to improve the flow of material through receiving with 33.4 percent of them reporting their efforts to be "considerable" or greater. Contractors have shifted to source inspections to permit material to avoid incoming inspection and proceed quickly through receiving. They have also taken steps to reduce the cycle time of the receiving and incoming inspection departments so materials that must pass through there do so as quickly as possible. Some have also instituted statistical sampling in lieu of 100 percent inspection to reduce the amount of inspection activity that must take place. Some contractors were working toward a certified supplier program to bypass receiving and inspection for contractors that can show their process is under control.

Administrative/Paperwork Requirement Reduction

Minimization of administrative and documentation requirements was the most restricted and least used JIT purchasing activity. Over 83 percent of the respondents reported restrictions. Government requirements mandate a considerable amount of documentation, both connected with the purchasing transaction and the flow of the material. The responses suggest that this documentation must be paper and that contractors may overkill somewhat on the documentation to be on the safe side. These pose obstacles for the JIT purchasing manager who wants to shift such administrative efforts to more productive uses. The restrictions appear to be almost overwhelming, since 70.8 percent indicated they were doing

very little or nothing in this area. Some were making some efforts, primarily by consolidating requirements, using long-term purchase agreements, and computer generation of purchasing documents. Some are working toward establishing a paperless purchasing system by using electronic data interchange. However, this has met with considerable government resistance. Contractors report that auditors and contract administration personnel are opposed to eliminating a paper audit trail. Reducing administrative and documentation requirements will likely pose a formidable challenge for JIT purchasers.

This section has searched for linkages between defense contracting practices and specific JIT production and purchasing activities. Because of that, most of the focus has been on limiting factors. However, it is important to note that the majority of the respondents experienced no problems with most of the contracting practices examined. The exceptions are the government's various controls over specifications and quality which impacted both production and purchasing negatively. In addition, most purchasing respondents also had problems with the government's subcontracting policy and audits. Overall, the restrictions do not appear to be as great as anticipated. Determined contractors are able to deal with most problems. The most serious challenges involve making engineering changes, making quality requirements more conducive to TQC, and dealing with the documentation and attitude problems associated with government audits. Moreover, most JIT production and purchasing activities seem to be exceptionally free from government restrictions and contractors have been able to implement most JIT production and purchasing activities without directly challenging government constraints.

This concludes the findings chapter of the dissertation. The next chapter provides a summary of the research findings. It also discusses the managerial and theoretical implications of the study, its limitations, and directions for future research.

CHAPTER 6

SUMMARY AND IMPLICATIONS

This chapter provides a summary of the research findings and addresses the implications of the research results. The first section summarizes the findings in terms of the two research questions and the hypotheses tested. The second section focuses on the managerial and theoretical implications that arise from the study. The last section addresses the limitations of the study and directions for future research.

Summary of Findings

This study focused on the impact of government contracting policies, practices, and requirements (or control mechanisms) on the JIT production and purchasing efforts of companies in the defense electronics industry. The researcher examined JIT projects carried out by five defense contractors to answer the following research questions:

> 1. What characteristics of the contract relationship significantly explain variances in 1) the impact of contracting policies, requirements, and practices on JIT production and purchasing efforts and 2) the extent of JIT production and purchasing activities undertaken?
>
> 2. What linkages exist between defense contracting policies, requirements, and practices and JIT production and purchasing activities?

This section summarizes the research findings for each research question.

Research Question One

The first research question focuses on the impact of the contracting environment on JIT production and purchasing efforts. This question presupposes there are characteristics of the contract relationship that determines the level and nature of government controls over the contractor which in turn impacts JIT activities. The relationship between the defense contractor and the government customer was defined in terms of the level of control the government imposed on the contractor, using two closely related theoretical models.

Williamson's Transaction Cost Economics (TCE) model focuses on the contractual nature of the buyer-seller relationship and provided the overall framework for the research model. A buyer-seller model developed by Landeros concentrates on the nature of the linkage between the buyer's and seller's systems. It was partially incorporated into the research model. Their approaches and contributions to the research model will be briefly reviewed prior to discussing the research findings.

Williamson suggested the most efficient contract relationship (governance structure) depends primarily on the extent to which highly specialized assets (asset specificity) are required to carry out the transaction, and secondarily on the uncertainty surrounding the transaction. As a transaction moves from the use of general purpose assets to more specialized ones, and as uncertainty increases, the parties to a contract can rely less and less on market forces to control the relationship and must substitute instead special administrative controls (more elaborated governance structures) to safeguard each one's interests. However, such administrative controls can be relaxed somewhat to the degree that the parties make credible commitments to bind each other to the successful completion of the transaction.[1] In this study, the defense contracting buyer-seller relationship was defined in terms of uncertainty, asset specificity, and commitment.

Landeros' theoretical model relates closely to TCE and was used to supplement it. He suggested the buyer-seller relationship could range from loosely coupled, independent systems, governed mostly by market forces, to very tightly coupled, interdependent systems, governed by cooperative arrangements. He suggested five variables that determine the degree of coupling: (1) supply pool, (2) credible commitment, (3) communication flow, (4) dispute resolution, and (5) marketplace adjustments.[2] The first three were incorporated into the research model. Supply pool was used as an indication of asset specificity, since larger supply pools suggest general use assets are being employed. Communication flow was used as an

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[1]Williamson, Economic Institutions, pp. 72-80, 167-169, 203-205.

[2]Landeros, pp. 4-8.

indicator of uncertainty resolution. Credible commitment is the same as in the Williamson model.

Drawing from these two models, the contract relationship was defined in terms of the cost uncertainty present (as indicated by contract type and contract amount), the uncertainty of contract requirements (the extent of communication/negotiation required before and after contract award); the degree of asset specificity present (as indicated by the government quality level required and the supply pool/competition available); and the commitment the contractor has made (in terms of asset ownership and financing). The research model suggested that as asset specificity, uncertainty and the contractor's reliance on government resources increases, contractors should face greater government administrative controls. Similarly, the contractor's system becomes more tightly coupled to that of the government and is more constrained by government requirements. In such cases, the contracting relationship should be less conducive to JIT implementation. In order to determine if this is true, four general hypotheses and sixteen sub-hypotheses were developed and tested concerning the relationships between the contract characteristics and the impact of government controls on JIT production and purchasing, and the extent to which JIT was implemented in the production and purchasing areas. The hypotheses and results of the tests are summarized in Table 26 and discussed in the paragraphs that follow.

Asset specificity, indicated by the quality level specified in the contract, emerged as the dominant determinant of the impact of government controls on JIT efforts. Contracts specifying the highest quality level (Mil-Q-9858) were associated with more restrictive government controls on JIT production efforts than contracts subject to lower quality levels. Similarly, the lowest quality level (contractor responsibility) was associated with a much less restrictive environment for JIT purchasing. Thus, increasingly specialized quality levels indicate greater asset specificity is present, generating a corresponding increase in government controls as the research model suggested. However, the role of asset specificity diminished when the extent of JIT implementation was considered, especially for purchasing.

Table 26

Summary of Hypothesis Tests

Hypothesis	Level of Support	Explanation of Results
H1: Contract requirements uncertainty (extent of preaward and/or postaward negotiations) increases impact of govt. controls and negatively impacts JIT efforts.	Weak	Results not consistent. Negatively impacts JIT implementation for production but not purchasing. Associated with increased impact of controls on purchasing but not production.
H1a: Significantly and positively related to impact of government controls on JIT production.	None	No support provided.
H1b: Significantly and negatively related to implementation of JIT production.	Moderate, mixed	Some indication that difficult postaward negotiations negatively impact JIT production efforts while difficult preaward negotiations have a positive effect.
H1c: Significantly and positively related to impact of government controls on JIT purchasing.	Quite Strong	Difficult preaward negotiations and, perhaps, postaward negotiations, positively related to the impact of govt. controls on JIT purchasing.
H1d: Significantly and negatively related to implementation of JIT purchasing.	None	No support provided.
H2: Cost uncertainty (contract type and/or amount) increases impact of government controls and negatively impacts JIT.	Moderate, Mixed	Contract type emerged as fairly significant for everything but the impact of controls on JIT purchasing. However, its relationship was consistently opposite from that hypothesized.
H2a: Significantly and positively related to impact of government controls on JIT production.	Moderate, Mixed	Contract type significant, but cost sharing arrangements negatively related to the impact of controls on JIT production.
H2b: Significantly and negatively related to implementation of JIT production.	Moderately Strong, Mixed	Contract type very significant, but cost sharing arrangements positively related to implementation of JIT production.

Table 28--Continued

Hypothesis	Level of Support	Explanation of Results
H2c: Significantly and positively related to impact of government controls on JIT purchasing.	None	No support provided.
H2d: Significantly and negatively related to implementation of JIT purchasing.	Weak, Mixed	Amount marginally significant but positively related to implementation of JIT purchasing.
H3: Asset specificity (little competition and/or specialized quality reqts.) increases impact of government controls and negatively impacts JIT.	Moderately Strong	Asset specificity, especially in the form of govt. quality reqts., had the hypothesized effect on all but JIT purchasing implementation.
H3a: Competition negatively related or quality level positively related to impact of government controls on JIT production.	Strong	Highest govt. quality reqts. significantly and positively related to impact of controls on JIT production. Competition less significant but negatively related.
H3b: Competition positively related or quality level negatively related to implementation of JIT production.	Moderate	Moderate govt. quality reqts. significantly and negatively related to implementation of JIT production. Highest level not significant.
H3c: Competition negatively related or quality level positively related to impact of government controls on JIT purchasing.	Strong	Highest govt. quality level significantly related to increased impact of controls; lowest level significantly related to decreased impact of controls.
H3d: Competition positively related or quality level negatively related to implementation of JIT purchasing.	None	No support provided.

Table 28--Continued

Hypothesis	Level of Support	Explanation of Results
H4: Reliance on govt. (assets and/or progress payments) increases impact of government controls and negatively impacts JIT.	Moderately Strong	The use of progress payments had the hypothesized effect on everything except the impact of government controls on JIT production.
H4a: Significantly and positively related to impact of government controls on JIT production.	None	No support provided.
H4b: Significantly and negatively related to implementation of JIT production.	Moderate	Progress payments significantly and negatively related to one indicator of implementation of JIT production. Some indication that govt. property also negatively related.
H4c: Significantly and positively related to impact of government controls on JIT purchasing.	Strong	Progress payments significantly and positively related to impact of controls on JIT purchasing.
H4d: Significantly and negatively related to implementation of JIT purchasing.	Strong	Progress payments significantly and negatively related to both indicators of JIT purchasing implementation.

Quality level was not a significant factor in the extent to which JIT purchasing was implemented but proved to have some impact on JIT production. However, it was the intermediate quality level, Mil-I-45208, that emerged as contributing negatively. Most of the JIT projects subject to Mil-I-45208 were located in Mil-Q-9858 qualified facilities and by company policy were held to the higher requirements even though not required by the contract. The products were quasi-commercial products and the respondents were frustrated that they could not achieve the level of JIT implementation they felt was possible for their products. Such perceptions may have contributed to lower evaluations of the extent of JIT reported. Overall, the role of asset specificity appears to be related to the level of

government controls for purchasing and production, but does not translate as strongly into direct impacts on JIT implementation.

The degree of commitment the contractor made, in terms of financial and physical resources also proved to have a significant impact on JIT efforts. The use of progress payments was associated with a more restrictive contracting environment for JIT purchasing and also proved to be the most significant and negative factor associated with the extent to which JIT purchasing was implemented. The use of progress payments also was associated negatively with the extent of JIT production but was not associated with the impact of government controls on JIT production. There were some indications that the use of government owned property also contributed negatively to the extent to which JIT production was implemented. Thus commitment is a determinant of the level of government controls over purchasing. However, the use of progress payments has a direct and negative impact on the extent of JIT implementation for both production and purchasing.

Cost uncertainty emerged as fairly significant in terms of its impact on JIT activities, but its role was different than hypothesized. The research model suggested that contracts with sharing arrangements and/or high dollar amounts, indicating higher levels of cost uncertainty, would subject the contractor to greater controls and thus negatively impact JIT efforts. However, JIT production projects operating with contractual cost incentives rated the impact of government controls as less severe than those operating under firm-fixed-price (FFP) contracts. This also carried over into the extent of JIT implementation with fixed-price-incentive (FPI) contracts contributing significantly and positively to the extent of JIT implementation for production. Incentive mechanisms apparently provide the motivation for JIT as well as the vehicle to deal with cost savings that eliminates fears that JIT cost savings will prompt accusations of defective pricing or criticisms of price gouging. On the purchasing side, cost uncertainty was not related to the level of government controls, but contract amount was directly related to the extent of JIT purchasing implementation. Apparently, high value contracts provide the incentive and the leverage for purchasing to conduct JIT activities but do not carry with them additional levels of government control as

the research model suggested. Since the average contract amount was over $140 million, the level of government controls may already be maximized.

Contract uncertainty did not emerge as a strong or consistent factor. There were some indications that difficult preaward negotiations contributed positively and difficult postaward negotiations contributed negatively to the extent to which JIT production was implemented. These were not significant in terms of the impact of government controls. Apparently difficult preaward negotiations provide some incentive to reduce costs and therefore conduct JIT activities. Difficult postaward negotiations occur as the result of contract changes which probably have a negative impact on the extent to which JIT production is implemented. In terms of purchasing, the extent of preaward negotiations was related to the negative impact of government controls on JIT purchasing. However, that did not appear to impact the extent of JIT purchasing. Thus, contract uncertainty is a determinant of the impact of government controls only for purchasing.

These findings suggest JIT production efforts are quite sensitive to the specific contracting environment. Specialized quality requirements, representing asset specificity, and contract type, representing cost uncertainty, were the most significant elements of the research model for production. Specialized quality requirements were associated with highly restrictive environments and also adversely impacted the extent of implementation. The presence of cost incentives moderately reduced the impact of government controls and greatly contributed to the extent of JIT implementation. Other variables were found to impact JIT implementation but were not associated with the level of government controls. The use of progress payments, indicating lower levels of contractor financial commitment, negatively impacted JIT production efforts. Preaward contract uncertainty was positively related to the extent of JIT implementation while postaward uncertainty had the opposite effect. Apparently, difficult preaward negotiations act as an incentive to JIT implementation while postaward changes are disruptive.

JIT purchasing activities are much less sensitive to the contract specific environment. As was the case with production, asset specificity (in the form of quality requirements) was

strongly associated with the level of government restrictions encountered. Next, in terms of significance, were contract uncertainty (difficult preaward negotiations) and commitment (progress payments). Of these, only progress payments were associated with the extent of JIT purchasing implementation. One other variable served to impact JIT implementation. Contract amount was positively related to the extent of JIT implementation in the purchasing area. Otherwise, the contract specific environment appears to have little impact on JIT purchasing. One reason for this might be that purchasing was centrally organized, while production was organized along product lines (and therefore highly contract specific). Further, the major government regulations purchasing must satisfy are general in nature, covering the purchasing process itself, and may overshadow contract specific requirements that manifest themselves as contract flow-down provisions. In addition, JIT purchasing activities are contract specific only to the extent that quality and delivery requirements are met. Most other JIT activities are more global in nature, focusing on the totality of the supplier relationship and performance over a longer period than the duration of the current government contract. This does not mean to suggest that JIT purchasing is not impacted by government controls, only that the contract specific environment does not drive purchasing as much as it drives production. The impact of specific government controls on both JIT production and purchasing efforts is the subject of the second research question.

Research Question Two

The second research question explored the relationships between specific contracting practices/control mechanisms and specific JIT activities. The following research questions were addressed:

R2a: Do government contracting policies, practices, and requirements have a greater impact on JIT purchasing activities than JIT production activities?

R2b: What relationships are there between contracting policies, practices, and requirements and JIT production activities?

R2c: What relationships are there between contracting policies, practices, and requirements and JIT purchasing activities?

The research findings regarding each question will be discussed in turn.

JIT Production and Purchasing Compared

Production and purchasing responses to twenty-one questions were compared to determine whether government controls impact JIT purchasing more severely than JIT production. These questions assessed the amount of government control encountered, the relative freedom to conduct JIT activities, and the impact of nineteen government controls (see Table 27) on their JIT efforts. The data suggested that purchasing respondents perceived themselves as falling under greater government control than did production respondents. However, their assessments of the freedom to conduct JIT activities were not significantly different. Concerning the impact of the nineteen contracting practices, there were significant differences for only two of them, namely, the government's engineering change procedures and the use of military standards. In both cases, JIT production received the most negative impact. One other contracting practice was somewhat significant. Purchasing rated progress payments more positively than production. However, the difference was minor. The findings do not warrant the conclusion that JIT purchasing efforts are impacted more than JIT production, even though purchasing may fall under greater government control.

JIT Production Activities

Research question R2b focused on the impact of government controls on specific JIT production activities. This question was analyzed by examining responses to questions relating to the impact of government controls on JIT production and the relative freedom to conduct specific JIT production activities.

Government controls did not have as much impact on JIT production activities as anticipated. Seven contracting practices were judged to have no impact on JIT production. Most of the respondents indicated the government's value engineering program, reporting requirements, progress payments, priorities systems, contract delivery requirements, and profit policy had no impact on their overall JIT efforts. In the case of the government's quality assurance representative (QAR), the responses were almost evenly divided between

Table 27

Impact of Government Controls on
JIT Production and Purchasing

Variable Definition	Production		Purchasing	
	Expected Impact	Actual Impact	Expected Impact	Actual Impact
G1 Govt. property	-	-	0	0
G2 Mil-Standards	-	-	-	0
G3 Govt. specification control	-	-	-	-
G4 Engineering change procedures	-	-	-	-
G5 Value Engineering program	+	0	+	0
G6 Contract quality requirements	-	-	-	-
G7 Govt. QA Representative (QAR)	-	0	?	-
G8 Cost Accounting Standards (CAS)	-	-	?	0
G9 Reporting requirements	-	0	-	-
G10 Contract changes	-	-	-	-
G11 Progress payments	-	0	-	0
G12 Socioeconomic programs	0	-	?	0
G13 Govt. subcontracting policy	?	-	-	-
G14 Govt. specified sources	?	-	-	0
G15 Disclosure of cost/pricing data	-	-	-	0
G16 Govt. audits/reviews	-	-	-	-
G17 Defense Priorities Systems	?	0	+	0
G18 Contract delivery requirements	+	0	?	0
G19 Govt. profit policy	-	0	-	0

NOTE: Symbols are used as follows: "0" for no impact, "-" for a negative impact, "+" for a positive impact, and "?" for unknown impact. Actual impacts were determined by comparing mean scores, with those more than two standard deviations above/below four (a rating of four meaning no impact) being rated as negative and positive impacts respectively. Mean scores falling within the two standard deviations were rated as no impact.

neutral, negative, and positive impacts. The QAR's impact was a function of the individuals involved.

Twelve practices had overall negative impacts on JIT. However, only four had at least half of the respondents rate them negatively. They are, in order of their rated impact: (1) engineering change procedures, (2) government control over specifications, (3) Mil-Standards, and (4) contract quality requirements. These controls restrict the contractor's ability to make the product, process, and quality changes suggested by JIT and statistical

process control. The government's emphasis on inspections and the use of lot acceptance sampling plans also restricted the flow of material by causing batching and increasing work-in-process inventories. These four major restrictions are serious because they impact the contractor's ability to make continuous improvements, the very core of the JIT philosophy.

The other eight practices had much less of a negative impact. The government's socioeconomic programs, subcontracting policy, and sourcing involvement were cited as causing purchasing problems and undependable supply. The complexity of the Cost Accounting Standards, especially in terms of labor reporting, was attributed to difficulties establishing a flexible work force. The use of government property was tied to controls that limited the contractor's flexibility in terms of its use and improvement. Contract changes, audits, and cost/pricing data requirements appeared to have a negative effect on overall operations and attitudes rather than impacting JIT activities specifically, although fear of audits and defective pricing charges could become a serious problem in terms of the motivation and staying power required to pursue JIT continuous improvement efforts.

Contractors experienced considerable freedom to conduct most JIT activities and that is usually reflected in the extent to which those activities were implemented. In general, contractors appeared to be free to establish short, structured flow paths through the use of efficient plant layouts, dedicated equipment, group technology, and focused factories. A few contractors experienced problems with government property, quality inspection requirements, and inadequate capital funding (attributed to low profits). In terms of implementation, contractors relied heavily on the use of dedicated equipment, focused factories, and efficient plant layout. Contractors also reported considerable freedom to maximize the capabilities and contributions of its workers by conducting such people leverage activities as developing a flexible work force and involving workers in quality circles or similar activities. Those activities were also among the most extensively implemented of all JIT activities. A few contractors complained of the government's emphasis on separate quality inspection and Mil-standard certification requirements as obstacles to further increasing worker flexibility. Contractors also experienced general freedom to conduct activities associated with achieving

linear operations (setup time reduction, pull system, lot size reduction, WIP reduction, linear production schedule). Contractors also used those activities quite extensively, especially lot size reduction, WIP reduction, and linear (drumbeat) production schedules.

Contractors encountered a little more difficulty achieving continuous flows by eliminating disruptions caused by poor quality or equipment problems. Insofar as total quality control activities are concerned, they were generally free to use statistical process control (SPC) and institute policies to stop production when defects occur, although quality system requirements and schedule pressure did cause a few problems. Contractors experienced considerable difficulty giving production workers total responsibility for quality due to government inspection and documentation requirements. In terms of implementation, contractors were able to make quite extensive use of all but SPC, which was just starting to be implemented in many of the facilities. Government controls over process and product specifications limited the ability of contractors to make the changes SPC identified. In a similar vein, contractors also experienced mixed levels of restrictions in conducting total productive maintenance activities. Contractors were almost totally free to institute preventive maintenance and involve operators in routine preventive maintenance activities. However, they felt quite restricted in improving equipment and processes, due to government controls over specifications. As a result, contractors made extensive use of preventive maintenance but did relatively little to improve processes and equipment. Operator involvement in routine preventive maintenance was also used sparingly, partly because the defense electronics industry is not equipment intensive and partly due to union and certification requirements.

Contractors' efforts to establish customer partnerships to achieve dependable demand were much more restricted less successfully implemented. Reducing administrative and documentation requirements and challenging government constraints were the most heavily restricted of all JIT activities. Close behind them was negotiating linear contract schedules. Customer requirements and unresponsiveness were identified as the primary problems. Contractors made some progress with the contract schedule issue but the other two were the

very lowest in terms of extent of implementation. The big question is whether the problem rests with the customers' resistance (or lack of interest) or the contractors' lack of initiative. Over 77 percent of the contractors rated themselves as restricted in challenging government constraints but 65 percent indicated they had little or no activity in that area.

In spite of the restrictions identified, contractors overall appear to be free to implement most of the JIT production activities and have been quite successful in doing so. Most have been able to extensively use most of the JIT activities examined without challenging government constraints to any large extent. Government controls in some areas, especially specifications and quality, tend to limit the flexibility and speed with which contractors can make changes. That is likely to become more of a problem as JIT implementation matures.

JIT Purchasing Activities

The impact of government contracting practices on JIT purchasing was somewhat less than anticipated. Only five contracting practices had a serious impact on JIT purchasing. Government controls over specifications and engineering change procedures adversely impacted the contractor's ability to make changes and increased the purchasing cycle time. The government's subcontracting policy, especially requirements for multiple sourcing and competitive bidding, somewhat restricted the development of close supplier relationships. Contract quality requirements were also identified as restrictive overall to purchasing but no consensus emerged as to its specific impact. Audits were the last activity that most seriously restricted JIT purchasing efforts. The documentation requirements caused increased cycle times and drained resources form JIT purchasing activities.

The other contracting practices had less serious impacts or no impact at all on JIT purchasing. The government's quality assurance representative, reporting requirements, and contract changes had enough negative ratings to be rated overall negative, although most respondents rated them as having no impact. They did not appear to cause very serious problems for JIT purchasing. Similarly, contract changes and reporting requirements

received an overall negative rating, but most of the respondents had little or no trouble with them. The mean scores for socioeconomic policies and government directed sources suggested they were not major problems, even though they were judged to negatively impact JIT production, primarily because of purchasing and supplier problems. However, purchasing evaluations were evenly divided between those who rated them as no impact or positively and those who rated them negatively. Later evaluations of specific JIT activities did identify these two areas as negatively impacting the development of local sources and reducing the vendor base. Thus, these two contracting practices may have a greater negative impact on JIT purchasing than initially indicated by the overall mean scores. The remaining government practices were judged by most respondents to not be problematical.

Contractors appear to have successfully dealt with government restrictions in implementing most JIT purchasing activities. In some cases, those activities that were least restricted resulted in more extensive implementation. That was the case with helping suppliers achieve total quality control. Contractors rated that as having the most freedom and that was also the most extensively used activity. However, helping suppliers incorporate JIT into their own operations, developing local suppliers, and achieving JIT deliveries were all rated as being restricted very little but had relatively low levels of implementation. It is unclear why contractors are not helping suppliers with JIT. Perhaps contractors fear them as competitors or lack the volume of purchases needed to capture the suppliers interest. It may also be that their JIT experience is not mature enough to export it to suppliers. Contractors were restricted somewhat their ability to develop local sources and achieve JIT deliveries due to the nature of the suppliers they have to deal. Contractors reported highly specialized electronics components are not conducive to local sources and their low volumes made it difficult to interest suppliers in making JIT deliveries. Further, directed sources were frequently not cooperative. Contractors faced even greater restrictions in reducing the supplier base and establishing long-term, close supplier relationships, especially from multiple sourcing and competitive bidding requirements. Yet many were able to find ways to achieve fairly high levels of implementation, at least according to their assessments.

Contractors reported heavy restrictions to streamlining inspection and receiving requirements, primarily due to quality and documentation requirements. However, they have been able to minimize those inspection and receiving requirements to a moderate extent, relying for the most part on source inspections. Finally, contractors' efforts to reduce administrative and documentation requirements and use single sources met with the greatest amount of restriction and were also the least extensive in terms of implementation.

Implications

This section addresses the managerial and theoretical implications of the findings. The managerial implications focus on the practical issues of implementing JIT production and purchasing in a defense contracting environment. This will focus on the implications for the defense contractor and the Department of Defense. The theoretical implications discuss the findings in terms of past and future research issues.

Managerial Implications

Defense Contractor

The first and probably most important implication from this study is that defense contractors are considerably free to implement most JIT activities. Most JIT production activities are either unrestricted or have only minor restrictions. Contractors are almost completely free to develop structured flow paths to shorten the flow of materials. Contractors by nature are highly focused and have a high degree of dedicated equipment. They are also almost totally free to develop group technology cells and arrange their layout for an efficient flow of materials. They are similarly free to develop a linear operation by reducing setup time, lot sizes, and work-in-process inventories; instituting a pull production control system; and developing a linear production schedule. They are also exceptionally free to increase the contribution of their employees through the development of cross-trained, flexible workers and the involvement of workers in quality circles or similar activities. Contractors are free to implement statistical process control, line stoppage for defects, and preventive maintenance, as well as to make the workers responsible for quality and the

upkeep of their work area to achieve a steady, continuous flow of material through the production system. The restrictions that were associated with these activities, for the most part, were minor.

The same holds true for many of the JIT activities associated with purchasing. Contractors are almost completely free to work with suppliers to achieve total quality control, help suppliers adopt the JIT philosophy, and schedule JIT deliveries. Defense contractors may not be in a position to do this with all suppliers, due to low volumes or unwilling qualified parts producers. Nevertheless, for those situations where vendors are willing and interested, there are very few government restrictions. Similarly, there are few restrictions to using local suppliers, where local suppliers are available or can be developed. There are some restrictions to reducing the supplier base, developing supplier partnerships, and single sourcing. However, many contractors found ways of doing it by working closely with sole sources, justifying the use of single sources, or (more commonly) prudently using competition with selection criteria based on quality, JIT delivery requirements, and cost. Contractors were able to award long-term contracts or contracts with options to develop quasi-supplier partnerships while still staying within the bounds of competitive bidding and multiple sourcing requirements. Streamlining the receiving function faces considerably more obstacles, but there are still opportunities for improvement. The heart of JIT is continuous improvement and contractors should be able to find better ways to work within the system, even without changing it.

That the contractors in the study were able to implement these activities considerably without challenging many constraints suggests a considerable amount of JIT implementation is possible within the contractors' current operating limits. If contractors believe that it cannot be done, the problem lies with their own perceptions than with government restrictions. There are some limitations and constraints.

An implication of this study is that there are limits, hopefully temporary, to achieving the full benefits of Total Quality Control. As suggested above, most TQC activities are not restricted. However, current quality requirements and attitudes are not supportive

of using certified operators to produce, inspect, and buy off the item they work on. It may be that the contractors in this study have not proven to the government that the process is under control sufficiently for them to have confidence in such a system. If so, time will solve the problem. If not, then contractors will have to challenge those constraints or else choose to live with the system and use duplicate inspection systems. Shifting the quality responsibility to production workers can still achieve quality benefits even if duplicate inspections are required.

A worrisome implication is that the process of changing specifications can be so difficult for defense contractors, that continuous improvement efforts may be slowed or severely limited. Contractors reported using statistical process control to identify needed improvements only to find they were not permitted to make them. Most, however, said changes were difficult, but not impossible. The implication is that contractors dealing with mature JIT systems, where most of the easier problems have been eliminated may find their JIT progress painfully slow as compared to their commercial counterparts. Contractors should first focus on their own internal cycle time for making such changes and then work with the customer to try and develop special change procedures to facilitate improvement. That should apply to regular engineering change procedures as well as those for value engineering.

Documentation requirements also can serve to limit a contractor's JIT progress in both the production and purchasing areas. In the defense industry, documentation can control the flow of material as much as processing and inspection requirements. This has important implications for several reasons. First, small lots of material flowing quickly between and through processes (also between supplier and contractor) cause a proliferation of documentation and can serve to limit the progress that can be made in that area. Further, capabilities are available to take advantage of electronic data transfer and storage to increase the speed and accuracy of communication and decrease the resources required to produce, store, and retrieve documents. Such advances could make great progress in reducing cycle time for production and purchasing. However, contractors report that auditors and contract

administration personnel are distrustful of electronic storage medium and want paper audit trails. Until such documentation requirements are modified, contractors may encounter some limits to the cycle time reductions that can be made.

Another implication involves progress payments. Both purchasing and production respondents gauged progress payments to have no impact on JIT efforts. However, the data suggested that contractors who use progress payments had less extensive implementations of JIT production and purchasing than those who did not. While progress payments can be used to good advantage without violating JIT principles, they can also be used to provide safety nets of inventory, largely financed by the government. Contractors implementing JIT should be aware of this dichotomy and guard against it if they choose to use progress payments.

The last implication involves constraints. The JIT philosophy of continual improvement and elimination of waste suggests that constraints must not be accepted but challenged. However, the findings of the study suggest that defense contractors are reluctant to do that. As suggested above, in order to achieve the full benefits of JIT, some constraints will have to be challenged. The most dangerous implication, however, is that the contractors' unwillingness to challenge government constraints dooms it to being limited by a constraint that may be only a phantom of someone's perception. Fifty percent of the production respondents and 54 percent of the purchasing respondents judged that most government constraints were perceived and not real. Unless contractors are willing to find out what the customer really wants or is willing to accept, they may unnecessarily restrict themselves. That suggests that contractors need to bring the government customer into the JIT process as much as possible.

DOD Managers

The implications discussed above suggest the contractor will have to engage the customers' support to gain the full benefits JIT can offer. While many benefits can be obtained without the customer's cooperation, government contractors will be limited in their improvement efforts if the customer does not support them. This section describes the

implications for the DOD manager responsible for some oversight with respect to the defense contractor trying to implement JIT.

One of the most important implications involves quality. The government's quality requirements and JIT have congruent goals of high quality. However, the means of achieving it are not totally compatible. The contractors that participated in this study perceive that the government is set on 100 percent inspection by separate quality inspectors and that precludes them from using certified operators to tie quality to the source of production, one of the basic tenets of JIT and TQC. Further, contractors wish to focus on statistical process controls rather than inspections. Reports have suggested all three military services were moving in that direction with Air Force General Monroe Smith being quoted as follows:

> No longer will we accept quality by inspection. Our contractors need to understand that their manufacturing process controls the quality of the products they are producing. We want them to maintain quality by inspecting the process.[3]

Defense contractors indicate that such policies have not been translated into action, at least at the operating level. When defense contractors have shown their ability to control quality by JIT/TQC methods, DOD managers should consider providing the latitude to use certified operators and statistical process control in lieu of separate inspection points so contractors (and the government) can achieve the full benefits of Total Quality Control. Otherwise, government quality controls may actually be counter productive.

Contractors are inhibited from making some of the changes JIT and statistical process controls identify because of the lengthy approval process associated with engineering changes proposals, value engineering proposals, and changes to mil-specs. If the DOD manager wants the contractor to make such improvements, then the process needs to be streamlined and the cycle time reduced. Contractors generally understand the need for controls and that all

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[3]Dan Beyers, "New Policy Would Control Product Quality," Air Force Times, June 18, 1987, p.55.

changes cannot be approved. However, they do need reasonably timely responses to their proposals or they are discouraged from even trying.

The findings suggested that contracts with cost sharing mechanisms were positively related to the extent that JIT was implemented. That does not mean that fixed-price-incentive contracts are preferred, but that contractors need a mechanism or some degree of trust that it can retain all or some cost savings without being charged explicitly or implicitly with defective pricing or over-pricing. The government's actions in terms of dealing with JIT cost savings serves to reward or penalize the contractor for its JIT efforts.

Documentation looms as an impediment to achieving the full benefits of JIT. Administrative and documentation requirements add cost and time to the production of a product. The JIT philosophy stresses that all non-value added activities should be eliminated and that includes much administrative and documentation requirements. However, contractors cannot make much headway in this area without customer support. When contractors try to reduce such requirements, the DOD manager will have to evaluate the costs and benefits of the documentation requirement and work with the contractor to balance the need for control and information with the costs in terms of dollars and cycle time. An especially important issue is the acceptability of electronic data storage in lieu of a paper audit trail. Certainly there must be a way to safeguard the government's interests without being shackled to obsolete methods.

The final implication is that the DOD customer has an important role to play in embracing the JIT philosophy. JIT offers considerable advantages for the defense industrial base, but only a few, innovative contractors are using it. The DOD as a customer could help contractors by providing DOD personnel that interface with contractors the needed awareness and training of JIT principles and practices so contractors can be encouraged and supported in their JIT continuous improvement efforts. The implication is actually even broader. The government could apply the JIT philosophy to all of its processes that interface with contractors to speed up the communication and contracting process. This was stressed by the findings and recommendations of the Packard Commission. It suggested the following:

> Chances for meaningful improvement will not come from more regulation but only with major institutional change. During the last decade or so a new theory of management has evolved. It has been developed by a limited number of U.S. companies, and has flourished in Japan. These new management practices have resulted in much higher productivity and much higher quality in the products being produced. They involve the participation of all of the people in the organization in deciding among themselves how the job can best be done. They involve , above all, trust in people. They involve the belief that people in an organization want to do a good job, and that they will--if given the opportunity--all contribute their knowledge, skill, and enthusiasm to work together to achieve the aims and goals of their organization. . . .
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> . . . .All too many people in DoD work in an environment of far too many laws, regulations, and detailed instructions about how to do their work. Far too many inspectors and auditors check their work, and there is a hierarchy of oversight in far too many layers, requiring much wasteful reporting and paperwork.[4]

The commission specifically suggested the defense acquisition process should be structured to emulate "commercial" practices, specifically by streamlining its process and cutting through red tape; simplifying federal statutes; relying on "off-the-shelf" items, rather than military specifications; using "commercial" style competition with an emphasis on quality, performance, and price; expanding the use of multi-year procurement to provide stability; and balancing costs and benefits of data requirements (including specifications). it further stressed the government should not impede contractors' efforts to improve their own performance.[5] These suggestions fall right in line with the findings of this study. If such recommendations were implemented, it should have a positive impact on contractors' Just-In-Time impiementation. Both contractor and customer would be better off.

Theoretical Implications

This section discusses the theoretical implications raised by the findings of this study, both in terms of past and future research. This will be done in terms of implications to defense contracting research, JIT research, and the buyer-seller models used as the theoretical constructs for this study.

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[4]President's Blue Ribbon Commission on Defense Management, A Quest for Excellence: Final Report to the President (Washington D.C.: Government Printing Office, 1986) pp.41-42.

[5]Ibid, pp.xxii-xxix.

Defense Contracting Research

Defense contracting is one of the largest purchasing activities in the United States. However, academic research in the area has been limited in number and sporadic. Research by Peck and Scherer, Scherer, and Fox focused their research on the largest defense contractors and major weapon systems. Gansler expanded his research to include a wider range of contractors and products. They all concluded that the government's involvement into the internal operations of the defense contractor was often counterproductive and contributed to inefficiency.[6] However, these researchers looked at the impact of government contracting policies and controls in a macro sense. This research focused on the impact of government controls on defense contractors trying to become more efficient. To some degree, the findings do suggest that government controls can inhibit a contractor's productivity and quality improvement efforts. This study identifies the most serious problem areas, which are, government controls over process and product specifications, quality, and subcontracting. These are important areas for future research. Other problem areas were also identified, but they are not nearly as pervasive and problematical. Issues concerning profit policy and related incentives also surfaced but did not prevail, overall. Thus, government controls as impediments to efficiency improvement do not appear to be too confining, at least for contractors dedicated to making such improvements. This research did not address motivational issues which may have been the crux of the previous research and certainly would be another avenue of important research.

In order to better determine the impact of government control mechanisms, their impacts need to be quantified with more objective data, such as measures of actual cycle time reduction, quality improvement, cost reduction, etc. This would require defense contractors to provide researchers with operating data. Further, if such information could also be obtained from comparable commercial operations, perhaps within the same companies, an

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[6]See Peck and Scherer, pp. 586-589; Scherer, pp. 1-12, 372-399; Fox, pp. 384-428; 449-450; and Gansler, pp. 72-96, 219-228.

even better picture would emerge concerning the impact of government regulations on a contractor's operations.

Another theoretical implication involves finding appropriate theoretical underpinnings for the defense contracting process. Past research has found that traditional economic models of markets is unsatisfactory for describing the defense contracting system because of the unique amount of control the buyer exerts over the internal operations of the seller.[7] In lieu of a theoretical model, the contract environment is classified by type of contractor, type of product, type of contract, etc. The research conducted uses terminology and structure highly specific to the defense contracting process. One implication of this study is that a more general contracting/buyer-seller theory is available and useful for describing the defense contracting environment and the relationship between the DOD and the defense contractor. This study shows that Williamson's Transaction Cost Economics model can be applied usefully to describe defense contracting control mechanisms (or governance structures in Williamson's terminology). The same applies to Landeros' system coupling model which can be used to evaluate how the government and the contractor interact from a systems perspective. This not only provides a useful structure for future research, but also serves as a vehicle for sharing research findings with, providing insight to, and obtaining insight from buyer-seller research that is not directly related to defense contracting.

The findings suggest that asset specificity is the most important factor determining the perceived level of government control over the contractor's operations, for both production and purchasing. That was very much in accordance with Williamson's TCE model. However, this suggests that the role of specialized assets plays a greater role than past research suggests. Peck and Scherer identified uncertainty as the most important characteristic making the defense contracting environment different.[8] However, they were

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[7]Peck and Scherer, pp. 56-60, 582-586; Scherer, pp.1-2; Fox, pp.26-39; Gansler, pp. 72-73.

[8]Peck and Scherer, pp. 17-54.

considering the research, development, and production of major weapon systems where uncertainty is high. The contractors in this study were in full production and uncertainty was not as high nor as important at that level. Uncertainty did play more of a role in terms of JIT implementation. These contractors were operating in an environment much closer to commercial marketing than those studied by Peck and Scherer. Gansler did find that asset specificity played an important role in terms barriers to entry into and exit from the defense industry.[9] That is really just a different way of looking at the problem. Low asset specificity implies lower barriers and simpler contract governance structures with which to deal.

While uncertainty did not emerge as the most significant characteristic of the contract relationship, it did prove to be of some importance as contributing positively to JIT implementation. Cost uncertainty, reflected by the presence of an incentive mechanism in the contract, contributed positively to JIT implementation, and in some cases to lower perceptions of government control. Scherer found such incentives not to be effective in motivating efficiency unless accompanied by low cost targets resulting from an unusually strong negotiation position on the part of the government.[10] His findings were confirmed by Fox a decade later.[11] However, defense contracting has changed since those research efforts were conducted, especially in the use of competition (or threat of it). Moreover, their research focused on major weapons systems, not on the production environment studied here. In addition, this research looked at programs where the contractor was already committed to increasing productivity and quality through JIT. This study suggests cost incentives can be important contributors to efficiency. There were also some indications that difficult preaward negotiations also contributed to the implementation of JIT production. It is possible that difficult preaward negotiations result in an important incentive to increase

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[9]Gansler, pp.46-50, 148-151.

[10]Scherer, pp. 230-236.

[11]Fox, pp.240-242.

efficiency and thus encourage JIT implementation. This would be consistent with the findings of Scherer.[12] In addition, difficult preaward negotiations may result in appropriate contract governance mechanisms that deal with the uncertainty and facilitate improvement.

Future research is needed to test the validity and the strength of the relationships described in this study. This needs to be done in other areas of the defense industry and include smaller defense contractors as well. In order to obtain a larger and more diverse sample, other productivity and quality improvement efforts would have to be examined in addition to those pursuing JIT.

Just-In-Time Research

This study also contributes to the JIT literature. Very little empirical research had been conducted when this research was developed. Celley et al. studied JIT implementation in the automotive industry. They found that JIT could be used across a wide range of process types and identified the most common implementation problems.[13] This research examined JIT in the electronics industry and adds a perspective from a different industry and process type. The implementation issues studied were quite different, since this research focused entirely on the impact of government controls as implementation barriers. However, there were some common areas, namely quality issues, inability to change paperwork systems, difficulty achieving JIT deliveries by suppliers, and inadequate equipment/tooling. These all surfaced, to some degree as implementation issues for defense contractors. Quality problems, in terms of government controls, were serious issues facing defense contractors. Defense contractors encountered severe difficulties in changing paperwork systems. Contractors also encountered some problems with equipment, but that was mostly due to government equipment. They also experienced some difficulties getting suppliers to make JIT deliveries. Defense contractors may also suffer some of the other obstacles identified in the Celley study, but they were not examined in this study.

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[12]Ibid, pp. 230-236.

[13]Celley et al., p.14.

Chapman conducted a study of JIT supplier relationships in the automotive industry. He found that suppliers who did not incorporate JIT improvement into their own operations were not able to efficiently meet JIT delivery requirements.[14] This study suggests that defense contractors are working with suppliers to achieve Total Quality Control but are leaving suppliers on their own to decide on incorporating JIT into their own operations. Thus, mature JIT partnerships are also lacking in the defense electronics industry.

The major implication this study makes regarding JIT is that it can be used under less than ideal circumstances, at least in the electronics industry. It examined JIT activities in an environment heavily controlled by the customer and subject to bureaucratic processes, identifying the impact that customer imposed parameters can have on a company's JIT activities. The contractors were able to readily use almost all of the JIT activities identified in the Heard model with the exception of establishing customer partnerships. The implication is, if a defense contractor can do it in such a restricted environment, any electronics producer should be able to benefit from JIT.

Buyer-Seller Models

The results of the study also have implications for the systems and transaction cost economics approach to buyer-seller relationships in a defense contracting environment. This was already somewhat addressed earlier in terms of its usefulness in conducting defense contracting research. The focus here is on the implications to the theoretical constructs derived from those approaches. The hypotheses tested in part the impact that asset specificity, uncertainty, and commitment have on the contractual governance structure and the tightness of the coupling between the DOD and the defense contractor and the corresponding impact on JIT implementation.

The findings generally support the transaction cost economics model. Williamson suggests that asset specificity is the most important characteristic of the transaction in determining the appropriate governance structure. Uncertainty and credible commitment

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[14]Chapman, pp.112-114.

then come into play[15] A variable representing asset specificity did emerge as the most important variable concerning the assessed impact of government control over production and purchasing operations. Contract type, representing cost uncertainty, also emerged as an important variable. Its sign was opposite from that hypothesized, but that merely suggests that an appropriate governance structure was selected. The hypotheses focused on the issue of controls, however, cost incentives appear to provide an appropriate mechanism for sharing costs and risks. Thus its role in the model was not specified correctly. The fairly strong support that the hypotheses relating to the level of contractor commitment also supports the applicability of Williamson's TCE model to defense contracting. Contractors unwilling to make credible commitments in terms of financing were subject to greater administrative controls, at least in the purchasing area.

The model also included three of the five components of the Landeros model, namely supply pool, credible commitment, and communication.[16] Competition was used to indicate the government's supply pool and did not appear as a significant variable. It was expected that the role of competition would be important both in terms of the level of government control and as a motivator to JIT. The research model focused on the level of government controls and the resulting impact on JIT. Normally, competition would signal a looser coupling between the government and the contractor, which is also associated with less extensive government control mechanisms. However, the contracts studied, for the most part were so large that they were negotiated instead of awarded on the basis of competition, thus eliminating the advantage that competition can produce in terms of alleviating those government controls. In such instances, competition may not impact the buyer-seller coupling, at least in the defense industry. The extent of preaward and postaward negotiation represented communication. Extensive preaward negotiation was significantly related to the impact of government controls on JIT purchasing, suggesting that it plays a role in defining

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[15]Williamson, Economic Institutions, pp. 52-56.

[16]Landeros, pp. 4-8.

the degree of coupling between purchasing and government. However, it did not impact JIT purchasing efforts so that the coupling must not be too strong. In terms of production, there were some indications that extensive preaward negotiation had a positive impact on JIT production while postaward communication had a negative impact. These were not associated with government controls but rather served as direct impacts on JIT production implementation. That provides support for the Landeros contribution to the model. The role of credible commitment was already covered as part of the TCE discussion. Its role was quite pronounced in terms of its impact on JIT implementation, both for production and purchasing giving strong support to this part of Landeros' model. Both models fit together quite nicely and are useful to study the defense contracting buyer-seller relationship in more generalized terms, which will be necessary if the defense contracting process is to be researched to the degree it deserves.

Limitations and Directions for Future Research

There are several limitations to this study which should be considered. First, the domain of the study was limited to the defense electronics industry. Thus, the findings can only be generalized to the impact of government control mechanisms on JIT production and purchasing efforts within that industry. While it is true that the government regulations are generally the same for all defense contractors, the products and processes associated with various industries vary as do the mil-standards applicable to them. The study was designed this way so that differences in products and processes would not confuse the results of the study and that the results would be a reflection of the contract characteristics. To the degree that this was successful, the generalizability of the findings could be extended. However, it will take future research to determine that for sure.

Another limitation involves the limited number of contractors available to participate in the study. That, plus time and financial restrictions, resulted in a sample of convenience rather than a true random sample from the defense electronics industry. This is counterbalanced somewhat by the fact that these contractors represent those with the most

experience implementing JIT in a true defense contracting environment. That was also true of the JIT projects selected for the study. The defense contractors determined what projects and what personnel the researcher would have access to. However, it is believed that the projects studied are representative of the contractors overall experience.

There are also some limitations that arise due to the nature of the data collected. Observational data in the form of subjective evaluations by the respondents were used. Structured interviews were used to minimize variation due to misunderstanding as much as possible and to get the most accurate data possible. Still, the individual's perceptions and subjective nature of the evaluations introduce an element of variability that would not be there if more objective measurements could be used. Objective measurements in terms of operating data was not universally available from all contractors. Thus, the findings are good only to the extent that individuals were honest and competent. The contractors provided their most experienced people and the interviews were held completely confidential to ensure the highest degree of honesty possible. Still, one must remember that all findings are based on the personal evaluations of the individuals interviewed.

Because of these limitations, this research should be viewed as initial findings, rather than conclusive results. Further research is needed to validate and test its findings. The study needs to be replicated using a larger sample of defense electronics contractors to test the findings in a confirmatory way. That may be difficult, however, since JIT has not been extensively implemented throughout the industry. Further, JIT experiences in other defense industries need to be examined to determine if the findings apply beyond the defense electronics industry. Replications using more objective and operational measures of JIT implementation are needed to eliminate the variation introduced into the study by subjective evaluations.

Additional research needs were discussed in the implications section. Several specific research questions are provided here as an indication of how future research can build on the groundwork established by this dissertation. These research questions involve defense

contracting issues, JIT issues, and theoretical issues. Future research is needed to answer the following:

1. Do the roles of asset specificity (quality level), commitment (progress payments), cost uncertainty (cost incentives/contract amount), and contract uncertainty (preaward/postaward negotiations) hold for JIT production and purchasing implementation in other areas of the defense industry, ie. producers of airplane parts/subsystems, ordnance, armored vehicles, tactical missiles, etc.?

2. Do the roles of asset specificity, commitment, cost uncertainty, and contract uncertainty hold for JIT production and purchasing implementation by major system and spare parts producers?

3. What are the roles of asset specificity, commitment, cost uncertainty, and contract uncertainty in terms of the implementation of other productivity improvement efforts, ie. Manufacturing Resources Planning (MRPII), Computer Aided Design/Computer Assisted Manufacturing(CAD/CAM), Computer Integrated Manufacturing (CIM), etc.?

4. Are the perceptions of defense contractors in terms of government obstacles to JIT implementation congruent with those of their government counterparts?

5. Controlling for time of implementation and industry, does the extent of JIT implementation differ between companies operating in the commercial and defense sectors? Can those differences be quantified?

6. Does the applicability of JIT production and purchasing and extent of implementation differ with respect to different defense industries.

7. What impact do government controls over quality have on actual quality levels achieved?

8. What motivates defense contractors to implement JIT into their production and purchasing functions? Does competition play a major role?

9. What role does the government's demand pattern have on JIT implementation, ie. does the continuity of production explain differences in the extent of JIT implementation?

10. What is the impact in terms of production costs, lead time, and quality of government controls over product and process specifications? What is the impact of the government's subcontracting policy?

Extensive research will be required before the impact of government controls on defense contractors' productivity and quality improvement efforts, in general, and their JIT efforts, in specific, are fully understood. The research conducted in this dissertation has opened the door of that understanding by a small crack.

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APPENDIX A

INTERVIEW INSTRUMENTS

DEFENSE INDUSTRY JIT SURVEY

COVER SHEET

SAMPLE INFORMATION

1. Contractor: _____
2. Operating Unit: _____
3. Part Number: _____
4. Nomenclature: _____
5. National Stock Number: _ _ _ _-_ _-_ _ _-_ _ _ _ (_ _)
6. Contract: _ _ _ _ _ _-_ _ _-_ _ _ _ (_____)

7. Person Interviewed: a) Name: _____

b) Position: _____

c) Office: _____

d) Telephone: _____

8. CALL RECORD

a) Call Number	1	2	3	4	5	6
b) Time of Day						
c) Month & Date						
d) Day of Week						
e) Result						

RA Respondent Absent
RB Respondent Busy
REF Refusal
INT Interview Taken
APP Appointment Made
P/ Partial
C/ Completed

9. Interview Time: Start_____ Stop_____ Duration_____

CHECKLIST:

___ 1. Cards in order?
___ 2. Definitions in place?
___ 3. Blank tape in recorder?
___ 4. Interview instrument ready?
___ 5. Writing instrument?

INTRODUCTION

This is an Arizona State University research project designed to assess the impact of defense contracting practices on productivity and quality improvement programs. This research project will form the basis of my Ph.D. dissertation. Your company was selected for this study because of its efforts to implement the Just-In-Time (Cycle-Time-Management) philosophy. Your cooperation is needed to successfully complete our research program. As a participant, you are entitled to a summary of the research findings.

The information gathered in this interview will be used for research and analysis purposes only. Individual responses are completely confidential. Data will be reported only in summarized form and will not contain any information that can be attributed to an individual, program, or company. No one from any organization will see any individual responses.

I am going to ask you a series of questions. In some cases, choices will be provided and you should indicate the most appropriate answer. In other cases, you will be asked to provide the answer on your own. Please answer all questions frankly and honestly but do not provide proprietary or classified information.

This interview will consist of three sections. The first concerns the nature of the contract(s) associated with the Product(s) benefitting from your JIT (CIM) activities. The second involves an assessment of the impact of government contracting policies, regulations, and practices on your JIT (CIM) efforts. The last section assesses the relative freedom you have to implement activities commonly associated with JIT (CIM) and the extent to which you have used those practices. Are you ready to begin?

OR

This interview will consist of two sections. The first involves an assessment of the impact of government contracting policies, regulations, and practices on your JIT (CIM) efforts. The second section assesses the relative freedom you have to implement activities commonly associated with JIT (CIM) and the extent to which you have used those activities. Are you ready to begin?

CONTRACTUAL RELATIONSHIP

The following questions relate to the nature of the contract(s) associated with this product.

1. What type of contract is typical for this product? ___ 7
   FFP FPE FPI FPR Other: _____ ___ 8

2. Does this contract have a cost incentive mechanism? ___ ___ ___ 9 10 11
   Yes No. (If yes) What is the share ratio?_____

3. [HAND OUT YELLOW CARD] Using the scale on this yellow card, please rate the negotiation effort required to obtain contracts for this product.

   NONE 1 2 3 4 5 6 7 EXTENSIVE ___ 12

4. Using the same scale, please rate the negotiation effort required to modify the contract as a result of changes in contract requirements after award. ___ 13

   NONE 1 2 3 4 5 6 7 EXTENSIVE

5. What is the amount of the basic contract, rounded to the nearest thousand dollars?_____ _____ 14-18

6. What is the defense priority rating?_____ ___ 19

7. What quality level is specified?
   ___Contractor Responsibility (FAR 46.202-1)
   ___Standard Inspection (FAR 46.202-1) ___ 20
   ___Higher Level (FAR 46.202-3)
   ___Higher Level (FAR 46.202-3)—Mil-I-45208
   ___Higher Level (FAR 46.202-3)—Mil-Q-9858

8. Are progress payments used? Yes No. (If yes) What is the payment rate?_____ ___ ___ 21 22

9. Who is the primary customer for this product?
   ___Air Force ___Other DOD/Govt. ___ 23
   ___Army ___Prime Contractor
   ___Navy ___Non-government

10. Of your total sales of this product, what percent do you sell to the DOD, both directly and through DOD prime contractors?_____ _____ 24-26

11. Please estimate the percentage of facilities, equipment, and tooling used to produce this product that is owned by the government or prime contractor _____. ____ 27-29

12. How many other companies typically compete for DOD contracts for this product?_____ ____ ____ 30 31

13. Are there any unique or unusual contractual arrangements associated with the production of this product? Yes No (If yes) What are they?

PRODUCTION

In this section I would like you to assess the impact of various defense contracting practices on your company's efforts to implement Just-In-Time (Cycle Time Management) principles.

1. First, using the seven point scale represented on this orange card [HAND OUT ORANGE CARD], what is the overall level of government regulation and control over your operations?

   No Control 1 2 3 4 5 6 7 Complete Control ____ 33

I am now going to name several practices associated with government contracting. Using the seven point scale on this tan card [HAND OUT CARD], indicate how the practice mentioned has impacted your JIT efforts. Use your best judgement and base your answer on actual occurrences where JIT practices have come into contact with government contracting policy, regulation, and practices. Following each assessment, you will be given the opportunity to explain your answer.

	N/A	STR -	MOD -	SOME -	NONE	SOME +	MOD +	STR +	
2. Govt. Owned Facilities, Tooling, & Equipment COMMENTS:	0	1	2	3	4	5	6	7	____ 34
3. Mil-Standards COMMENTS:	0	1	2	3	4	5	6	7	____ 35
4. Govt. Control over Specifications COMMENTS:	0	1	2	3	4	5	6	7	____ 36
5. Govt's Engineering Change Procedures COMMENTS:	0	1	2	3	4	5	6	7	____ 37
6. Govt's Value Engineering Program COMMENTS:	0	1	2	3	4	5	6	7	____ 38

	N/A	STR -	MOD -	SOME -	NONE	SOME +	MOD +	STR +	
7. Contract Quality Requirements COMMENTS:	0	1	2	3	4	5	6	7	39
8. Govt. Quality Assurance Representative COMMENTS:	0	1	2	3	4	5	6	7	40
9. Cost Accounting Standards COMMENTS:	0	1	2	3	4	5	6	7	41
10. Reporting Requirements COMMENTS:	0	1	2	3	4	5	6	7	42
11. Required Changes & Modifications to Contract COMMENTS:	0	1	2	3	4	5	6	7	43
12. Government Financing & Related Controls COMMENTS:	0	1	2	3	4	5	6	7	44
13. Govt. Socioeconomic Programs COMMENTS:	0	1	2	3	4	5	6	7	45

	N/A	STR -	MOD -	SOME -	NONE	SOME +	MOD +	STR +	
14. Govt. Subcontracting Policy (Procurement Policy for Purchased Parts/Services) COMMENTS:	0	1	2	3	4	5	6	7	46
15. Govt. Specified or Approved Sources COMMENTS:	0	1	2	3	4	5	6	7	47
16. Required Disclosure of Cost/Pricing Data COMMENTS:	0	1	2	3	4	5	6	7	48
17. Govt. Audits & Reviews COMMENTS:	0	1	2	3	4	5	6	7	49
18. Defense Materials System/Defense Priorities System COMMENTS:	0	1	2	3	4	5	6	7	50
19. Contract Delivery Requirements COMMENTS:	0	1	2	3	4	5	6	7	51
20. Profit Policy COMMENTS:	0	1	2	3	4	5	6	7	52

This completes this section of the study. Are you ready to begin the last section?

JIT PRODUCTION ACTIVITIES

Now let's shift our attention to the JIT (CIM) activities you have conducted.

21. For how many months have you been implementing (using) JIT (CIM) methods for this product? _____. 54-55

Now I am going to name activities commonly associated with JIT (CIM). For each activity, please provide two responses. First, using the seven point scale on this green card [HAND OUT CARD] please assess the relative freedom from government restriction you have to conduct each activity. Then, using the seven point scale on this pink card [HAND OUT PINK CARD], indicate the extent to which your company has implemented the activity. After these responses you will be given the opportunity to explain your answers.

22. Arranging the plant layout to minimize the distance material travels
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd — 56

None 1 2 3 4 5 6 7 Total — 57

23. Assigning equipment exclusively to products or product families to facilitate material flow
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd — 58

None 1 2 3 4 5 6 7 Total — 59

24. Application of Group Technology
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd — 60

None 1 2 3 4 5 6 7 Total — 61

25. Use of focused factories (mfg. facilities focused on a narrow range of related products using the same processes and technologies)
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd — 62

None 1 2 3 4 5 6 7 Total — 63

26. Development of cross-trained, flexible workers
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd ___ 64

None 1 2 3 4 5 6 7 Total ___ 65

27. Use of Quality Circles or similar activities to involve workers in quality/process improvement
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd ___ 66

None 1 2 3 4 5 6 7 Total ___ 67

28. Use of Statistical Process Control
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd ___ 68

None 1 2 3 4 5 6 7 Total ___ 69

29. Stop production when abnormal or defective products or conditions are detected
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd ___ 70

None 1 2 3 4 5 6 7 Total ___ 71

30. Making production workers responsible for quality, including inspection
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd ___ 72

None 1 2 3 4 5 6 7 Total ___ 73

31. Aggressive preventive maintenance program
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd — 74

None 1 2 3 4 5 6 7 Total — 75

32. Improving the processing capability and maintainability of equipment
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd — 76

None 1 2 3 4 5 6 7 Total — 77

33. Operator involvement in routine preventive maintenance & inspection
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd — 78

None 1 2 3 4 5 6 7 Total — 79

34. Setup time reduction
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd — 80

None 1 2 3 4 5 6 7 Total — 81

35. Lot size or batch reduction
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd — 82

None 1 2 3 4 5 6 7 Total — 83

36. Installation of a "pull" production control system (where each process produces items needed by the next process only when a demand signal is received by that process)
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd ___ 84

None 1 2 3 4 5 6 7 Total ___ 85

37. Reduction of Work-In-Process Inventories
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd ___ 86

None 1 2 3 4 5 6 7 Total ___ 87

38. Achieving a linear or drum beat production rate (a relatively smooth production rate with production quotas in short time increments and no over- or under-production)
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd ___ 88

None 1 2 3 4 5 6 7 Total ___ 89

39. Establishing contract delivery schedules with frequent deliveries of small quantities to customer
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd ___ 90

None 1 2 3 4 5 6 7 Total ___ 91

40. Changing government contracting policies, practices, and requirements that are not supportive of JIT
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd ___ 92

None 1 2 3 4 5 6 7 Total ___ 93

41. Reduction of administrative and paperwork requirements
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd ___ 94

None 1 2 3 4 5 6 7 Total ___ 95

42. What is your overall assessment of your JIT (CIM) efforts in terms of freedom from government restriction and extent of application?
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd ___ 96

None 1 2 3 4 5 6 7 Total ___ 97

You will not need to refer to the cards any longer. I have just three more questions.

43. If you could change five things in the way the government does business to make JIT implementation much easier, what would those changes be?

1.

2.

3.

4.

5.

Now, please rank them in order of priority, with "1" being the most important.

44. What recommendations would you have for another project manager trying to implement JIT in a similar contracting environment?

45. In regards to the impact of government contracting practices on JIT (CIM) efforts, would you say the greatest problem involves actual government caused obstacles or perceived obstacles?

Thank you for your participation. Again, I want to assure you that all responses will be held in absolute confidence. I mentioned earlier that you would be eligible to receive a summary of the research findings. Do you wish to receive a copy? YES NO. (IF YES) What address should I send it to?

Do you have any further comments or questions?

CHECKLIST:

____ 1. Gather cards.

____ 2. Get recorder.

PURCHASING

I would like you to assess the impact of various defense contracting practices on your company's purchasing activities to support your company's JIT (CIM) production efforts. If you have implemented JIT (CIM) purchasing principles, I want you to consider the impact on those efforts.

1. First, I would like you to assess the overall level of government regulation and control over your operations using the seven point scale represented on this orange card [HAND OUT ORANGE CARD].

   No Control 1 2 3 4 5 6 7 Complete Control ____ 33

I am now going to name several practices associated with government contracting. Using the seven point scale on this tan card [HAND OUT CARD], indicate how the practice mentioned has impacted your purchasing efforts to support JIT production. Use your best judgement and base your answer on actual occurrences where JIT practices have come into contact with government contracting policy, regulation, and practices. Following each assessment, you will be given the opportunity to explain your answer.

	N/A	STR -	MOD -	SOME -	NONE	SOME +	MOD +	STR +	
2. Govt. Owned Facilities, Tooling, & Equipment COMMENTS:	0	1	2	3	4	5	6	7	____ 34
3. Mil-Standards COMMENTS:	0	1	2	3	4	5	6	7	____ 35
4. Govt. Control over Specifications COMMENTS:	0	1	2	3	4	5	6	7	____ 36
5. Govt's Engineering Change Procedures COMMENTS:	0	1	2	3	4	5	6	7	____ 37
6. Govt's Value Engineering Program COMMENTS:	0	1	2	3	4	5	6	7	____ 38

	N/A	STR -	MOD -	SOME -	NONE	SOME +	MOD +	STR +	
7. Contract Quality Requirements COMMENTS:	0	1	2	3	4	5	6	7	39
8. Govt. Quality Assurance Representative COMMENTS:	0	1	2	3	4	5	6	7	40
9. Cost Accounting Standards COMMENTS:	0	1	2	3	4	5	6	7	41
10. Reporting Requirements COMMENTS:	0	1	2	3	4	5	6	7	42
11. Required Changes & Modifications to Contract COMMENTS:	0	1	2	3	4	5	6	7	43
12. Government Financing & Related Controls COMMENTS:	0	1	2	3	4	5	6	7	44
13. Govt. Socioeconomic Programs COMMENTS:	0	1	2	3	4	5	6	7	45

	N/A	STR -	MOD -	SOME -	NONE	SOME +	MOD +	STR +	
14. Govt. Subcontracting Policy (Procurement Policy for Purchased Parts/Services) COMMENTS:	0	1	2	3	4	5	6	7	46
15. Govt. Specified or Approved Sources COMMENTS:	0	1	2	3	4	5	6	7	47
16. Required Disclosure of Cost/Pricing Data COMMENTS:	0	1	2	3	4	5	6	7	48
17. Govt. Audits & Reviews COMMENTS:	0	1	2	3	4	5	6	7	49
18. Defense Materials System/Defense Priorities System COMMENTS:	0	1	2	3	4	5	6	7	50
19. Contract Delivery Requirements COMMENTS:	0	1	2	3	4	5	6	7	51
20. Profit Policy COMMENTS:	0	1	2	3	4	5	6	7	52

This completes this section of the study. Are you ready to begin the last section?

PURCHASING ACTIVITIES

This section addresses purchasing activities commonly associated with JIT purchasing. By JIT purchasing I am referring to such activities as helping suppliers incorporate JIT (CIM) and quality control principles, reducing the supplier base to include only the best vendors, establishing long-term supplier partnerships, and developing delivery patterns such that high quality purchasing parts are delivered frequently and in small quantities to meet only the "immediate needs" of production.

21. Has your company tried to adopt Just-In-Time (Cycle Time Management) Purchasing methods? Yes No. (If yes) How many months have you been implementing (using) these methods?_____. 53-54

Now I am going to name activities commonly associated with JIT (CIM) purchasing. For each activity, please provide two responses. First, using the seven point scale on this green card [HAND OUT CARD] please assess the relative freedom from government restriction you have to conduct each activity. Then, using the seven point scale on this pink card [HAND OUT PINK CARD], indicate the extent to which your company has implemented the activity. After these responses you will be given the opportunity to explain your answers.

22. Working with suppliers to achieve Total Quality Control
COMMENTS:

Not Rest'd Rest'd
1 2 3 4 5 6 7 55

None Total
1 2 3 4 5 6 7 56

23. Helping suppliers apply JIT (CIM) principles to their own operations
COMMENTS:

Not Rest'd Rest'd
1 2 3 4 5 6 7 57

None Total
1 2 3 4 5 6 7 58

24. Reduction of supplier base to include only the very best suppliers
COMMENTS:

Not Rest'd Rest'd
1 2 3 4 5 6 7 59

None Total
1 2 3 4 5 6 7 60

25. Establishment of long-term partnerships/contracts with preferred suppliers
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd ___ 61

None 1 2 3 4 5 6 7 Total ___ 62

26. Increased use of and preference for single sourcing in lieu of multiple sourcing
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd ___ 63

None 1 2 3 4 5 6 7 Total ___ 64

27. Preference for local or geographically close suppliers
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd ___ 65

None 1 2 3 4 5 6 7 Total ___ 66

28. Suppliers make frequent deliveries in small quantities, enough to satisfy production's "immediate" needs
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd ___ 67

None 1 2 3 4 5 6 7 Total ___ 68

29. Minimization of receiving requirements so deliveries proceed directly to production with minimal inspection and handling requirements
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd ___ 69

None 1 2 3 4 5 6 7 Total ___ 70

30. Reduction of administrative and paperwork requirements
COMMENTS

Not Rest'd 1 2 3 4 5 6 7 Rest'd ___ 71

None 1 2 3 4 5 6 7 Total ___ 72

31. Now provide an overall assessment of the freedom from government restriction to undertake JIT (CIM) purchasing activities and the extent to which you have implemented JIT (CIM) purchasing
COMMENTS:

Not Rest'd 1 2 3 4 5 6 7 Rest'd ___ 73

None 1 2 3 4 5 6 7 Total ___ 74

You will not need to refer to the cards any longer. I have just three more questions.

32. If you could change five things in the way the government does business to make it easier to implement JIT purchasing (make your purchasing efforts more efficient and productive), what would they be?

1.

2.

3.

4.

5.

Now prioritize them in order of importance, with "1" being the most important and "5" the least.

33. What recommendations would you make to other purchasing departments trying to support JIT production efforts?

34. In regards to the impact of government contracting practices on JIT (CIM) efforts, would you say the greatest problem involves actual government caused obstacles or perceived obstacles?

Thank you for your support in this research project. I want to assure you one more time that all responses will be held in the utmost confidence. I mentioned earlier that you would be eligible to receive a summary of the research findings. Do you wish to receive a copy? YES NO. (IF YES) What address should I send it to?

Do you have any further questions or comments?

CHECKLIST:

___ 1. Gather cards.

___ 2. Get recorder.

APPENDIX B

T-TESTS AND MANN-WHITNEY TESTS FOR DIFFERENCES IN PRODUCTION AND PURCHASING RESPONSES

T-TESTS FOR DIFFERENCES IN PRODUCTION AND PURCHASING RESPONSES

Group 1: PRODUCTION Group 2: PURCHASING

t-test for: G1 Government Owned Facilities & Equipment

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	29	4.3793	.728	.135
Group 2	14	4.1429	1.292	.345

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
3.15	.011	.77	41	.446	.64	17.10	.532

t-test for: G2 Mil-Standards

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	39	5.0769	1.133	.181
Group 2	24	4.5000	1.383	.282

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
1.49	.269	1.80	61	.076	1.72	41.62	.093

t-test for: G3 Government Control Over Specifications

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	33	5.2121	1.219	.212
Group 2	21	4.8095	1.250	.273

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
1.05	.876	1.17	52	.247	1.17	41.93	.251

t-test for: G4 Engineering Change Procedures

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	33	5.7273	1.329	.231
Group 2	21	4.9524	.973	.212

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
1.86	.146	2.30	52	.025	2.47	50.86	.017

t-test for: G5 Value Engineering Program

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	30	3.8667	.819	.150
Group 2	19	3.8421	.688	.158

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
1.42	.443	.11	47	.914	.11	43.21	.911

t-test for: G6 Contract Quality Requirements

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	40	5.0750	1.347	.213
Group 2	24	4.7083	1.367	.279

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
1.03	.913	1.05	62	.298	1.04	48.01	.301

t-test for: G7 Government Quality Assurance Representat

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	39	4.3333	1.243	.199
Group 2	21	4.4286	.811	.177

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
2.35	.044	-.32	58	.753	-.36	55.70	.722

t-test for: G8 Cost Accounting Standards

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	40	4.4250	1.259	.199
Group 2	24	4.1667	.702	.143

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
3.21	.004	.92	62	.360	1.05	61.77	.296

t-test for: G9 Reporting Requirements

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	34	4.1176	.591	.101
Group 2	22	4.3636	.790	.168

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
1.78	.133	-1.33	54	.189	-1.25	35.98	.219

t-test for: G10 Contract Changes/Modifications

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	39	4.4872	.914	.146
Group 2	22	4.4545	.912	.194

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
1.01	1.000	.13	59	.894	.13	43.78	.894

t-test for: G11 Progress Payments & Related Controls

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	32	4.1875	1.120	.198
Group 2	18	3.6667	.970	.229

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
1.33	.540	1.65	48	.105	1.72	39.78	.093

t-test for: G12 Socioeconomic Programs

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	40	4.4500	.959	.152
Group 2	23	4.3043	1.396	.291

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
2.12	.040	.49	61	.626	.44	34.15	.660

t-test for: G13 Subcontracting Policy

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	39	4.6667	1.108	.177
Group 2	22	4.8182	1.259	.268

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
1.29	.483	-.49	59	.627	-.47	39.23	.640

t-test for: G14 Government Specified/Approved Sources

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	26	4.6538	1.018	.200
Group 2	15	4.6000	1.352	.349

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
1.77	.208	.14	39	.886	.13	23.25	.895

t-test for: G15 Cost & Pricing Data

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	37	4.4054	.927	.152
Group 2	22	4.0909	.921	.196

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
1.01	1.000	1.26	57	.212	1.27	44.49	.212

t-test for: G16 Government Audits/Reviews

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	39	4.5897	.910	.146
Group 2	23	4.7391	.810	.169

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
1.26	.571	-.65	60	.518	-.67	50.66	.506

t-test for: G17 Defense Materials System/Priorities Syst

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	40	4.0500	.552	.087
Group 2	23	4.0000	1.314	.274

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
5.66	.000	.21	61	.833	.17	26.54	.863

t-test for: G18 Contract Delivery Requirements

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	40	4.0250	1.025	.162
Group 2	24	4.0833	1.530	.312

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
2.23	.027	-.18	62	.856	-.17	35.54	.869

t-test for: G19 Government's Profit Policy

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	40	4.1500	.921	.146
Group 2	24	4.1667	.637	.130

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
2.09	.063	-.08	62	.938	-.09	60.63	.932

t-test for: CONTROL

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	40	4.5500	1.037	.164
Group 2	24	5.0833	.881	.180

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
1.39	.410	-2.10	62	.039	-2.19	54.80	.033

t-test for: FREEDOM

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	40	3.4250	1.059	.168
Group 2	24	3.2500	1.327	.271

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
1.57	.211	.58	62	.563	.55	40.47	.586

MANN-WHITNEY TESTS FOR DIFFERENCES IN
PRODUCTION AND PURCHASING RESPONSES

G1 Government Owned Facilities & Equipment
by FUNCTION

Mean Rank	Cases		
22.09	29	FUNCTION = 1	Production
21.82	14	FUNCTION = 2	Purchasing
	43	Total	

U	W	Corrected for Ties Z	2-tailed P
200.5	305.5	-.0711	.9434

G2 Mil-Standards
by FUNCTION

Mean Rank	Cases		
34.99	39	FUNCTION = 1	Production
27.15	24	FUNCTION = 2	Purchasing
	63	Total	

U	W	Corrected for Ties Z	2-tailed P
351.5	651.5	-1.6957	.0899

G3 Government Control Over Specifications
by FUNCTION

Mean Rank	Cases		
29.09	33	FUNCTION = 1	Production
25.00	21	FUNCTION = 2	Purchasing
	54	Total	

U	W	Corrected for Ties Z	2-tailed P
294.0	525.0	-.9624	.3358

G4 Engineering Change Procedures
by FUNCTION

Mean Rank	Cases		
31.97	33	FUNCTION = 1	Production
20.48	21	FUNCTION = 2	Purchasing
	54	Total	

		Corrected for Ties	
U	W	Z	2-tailed P
199.0	430.0	-2.7017	.0069

G5 Value Engineering Program
by FUNCTION

Mean Rank	Cases		
25.25	30	FUNCTION = 1	Production
24.61	19	FUNCTION = 2	Purchasing
	49	Total	

		Corrected for Ties	
U	W	Z	2-tailed P
277.5	467.5	-.1933	.8467

G6 Contract Quality Requirements
by FUNCTION

Mean Rank	Cases		
34.64	40	FUNCTION = 1	Production
28.94	24	FUNCTION = 2	Purchasing
	64	Total	

		Corrected for Ties	
U	W	Z	2-tailed P
394.5	694.5	-1.2255	.2204

G7 Government Quality Assurance Representat
by FUNCTION

Mean Rank	Cases		
30.72	39	FUNCTION = 1	Production
30.10	21	FUNCTION = 2	Purchasing
	60	Total	

U	W	Corrected for Ties Z	2-tailed P
401.0	632.0	-.1382	.8901

G8 Cost Accounting Standards
by FUNCTION

Mean Rank	Cases		
33.75	40	FUNCTION = 1	Production
30.42	24	FUNCTION = 2	Purchasing
	64	Total	

U	W	Corrected for Ties Z	2-tailed P
430.0	730.0	-.7758	.4379

G9 Reporting Requirements
by FUNCTION

Mean Rank	Cases		
26.69	34	FUNCTION = 1	Production
31.30	22	FUNCTION = 2	Purchasing
	56	Total	

U	W	Corrected for Ties Z	2-tailed P
312.5	688.5	-1.2754	.2022

G10 Contract Changes/Modifications
by FUNCTION

Mean Rank	Cases		
31.12	39	FUNCTION = 1	Production
30.80	22	FUNCTION = 2	Purchasing
	61	Total	

U	W	Corrected for Ties Z	2-tailed P
424.5	677.5	-.0801	.9362

G11 Progress Payments & Related Controls
by FUNCTION

Mean Rank	Cases		
27.94	32	FUNCTION = 1	Production
21.17	18	FUNCTION = 2	Purchasing
	50	Total	

U	W	Corrected for Ties Z	2-tailed P
210.0	381.0	-1.7628	.0779

G12 Socioeconomic Programs
by FUNCTION

Mean Rank	Cases		
32.75	40	FUNCTION = 1	Production
30.70	23	FUNCTION = 2	Purchasing
	63	Total	

U	W	Corrected for Ties Z	2-tailed P
430.0	706.0	-.4621	.6440

G13 Subcontracting Policy
by FUNCTION

Mean Rank	Cases	
29.78	39	FUNCTION = 1 Production
33.16	22	FUNCTION = 2 Purchasing
	61	Total

		Corrected for Ties	
U	W	Z	2-tailed P
381.5	729.5	-.7649	.4443

G14 Government Specified/Approved Sources
by FUNCTION

Mean Rank	Cases	
21.37	26	FUNCTION = 1 Production
20.37	15	FUNCTION = 2 Purchasing
	41	Total

		EXACT	Corrected for Ties	
U	W	2-tailed P	Z	2-tailed P
185.5	305.5	.7995	-.2728	.7850

G15 Cost & Pricing Data
by FUNCTION

Mean Rank	Cases	
31.84	37	FUNCTION = 1 Production
26.91	22	FUNCTION = 2 Purchasing
	59	Total

		Corrected for Ties	
U	W	Z	2-tailed P
339.0	592.0	-1.4705	.1414

G16 Government Audits/Reviews
by FUNCTION

Mean Rank	Cases		
29.73	39	FUNCTION = 1	Production
34.50	23	FUNCTION = 2	Purchasing
	62	Total	

		Corrected for Ties	
U	W	Z	2-tailed P
379.5	793.5	-1.1233	.2613

G17 Defense Materials System/Priorities Syst
by FUNCTION

Mean Rank	Cases		
32.54	40	FUNCTION = 1	Production
31.07	23	FUNCTION = 2	Purchasing
	63	Total	

		Corrected for Ties	
U	W	Z	2-tailed P
438.5	714.5	.3933	.6941

G18 Contract Delivery Requirements
by FUNCTION

Mean Rank	Cases		
31.69	40	FUNCTION = 1	Production
33.85	24	FUNCTION = 2	Purchasing
	64	Total	

		Corrected for Ties	
U	W	Z	2-tailed P
447.5	812.5	-.4983	.6183

G19 Government's Profit Policy
by FUNCTION

Mean Rank	Cases		
32.76	40	FUNCTION = 1	Production
32.06	24	FUNCTION = 2	Purchasing
	64	Total	

U	W	Corrected for Ties Z	2-tailed P
469.5	769.5	-.1917	.8480

CONTROL
by FUNCTION

Mean Rank	Cases		
28.46	40	FUNCTION = 1	Production
39.23	24	FUNCTION = 2	Purchasing
	64	Total	

U	W	Corrected for Ties Z	2-tailed P
318.5	941.5	-2.4621	.0138

FREEDOM
by FUNCTION

Mean Rank	Cases		
33.09	40	FUNCTION = 1	Production
31.52	24	FUNCTION = 2	Purchasing
	64	Total	

U	W	Corrected for Ties Z	2-tailed P
456.5	756.5	-.3760	.7069

APPENDIX C

SUMMARIES OF OPEN-ENDED RESPONSES

IMPACT OF CONTRACTING PRACTICES ON PRODUCTION

Negative Assessments	Positive Assessments
G1 Government Furnished Property	
-Restricted to specific contracts so hard to use on other contracts (7)	+Provides dedicated equipment (2)
-Tends to be resource limited, causing bottlenecks (2)	
-Can't change easily (1)	
-Overregulated (1)	
G2 Mil-Standards	
-Inspection criteria disrupts material flow and limits flexibility (8)	+Soldering specs improve quality (1)
-Restricts ability to solve problems (6)	+Makes things easier (1)
-Standards are outdated and often conflicting (3)	+Provides needed information but increases cycle time (1)
-Cause parts shortages (2)	+Contractor builds to higher level than required by mil-stds. (1)
-Ambiguous requirements need interpretation (2)	
-Force batching (2)	
-Solder specs too difficult to meet(2)	
-Superfluous inspection requirements (1)	
-Sometimes not cost effective (1)	
-Lengthens procurement cycle (1)	
G3 Govt. Control over Specifications	
-Lengthy change process inhibits cycle time reduction (9)	+Promotes consistency (1)
-Limits continuous improvement efforts (5)	
-Minor deviations not impacting quality or reliability very disruptive (2)	
-Quality overspecification increases cycle time (1)	
-Some specs too difficult (1)	
-Excessive controls cause inefficiency (1)	
-Solder specs (1)	
G4 Engineering Change Procedures	
-Long approval process makes it too hard to make changes (23)	+Special change procedures established to facilitate change (1)
-Customer resistent to change (2)	
-Excessive approval and documentation reqts. (2)	
-Changes adversely impact production schedule (1)	

G5 Value Engineering Program

-Approval process too slow to recoup investment (3)

+Beneficial early in life cycle (3)
+Successfully made positive changes (1)

G6 Contract Quality Requirements

-Required inspection points/documentation impede material flow (11)
-Disagreements/questions take too long to resolve (5)
-Forces unnecessary, over-specified inspection criteria (5)
-Overly restrictive, not conducive to change (4)
-Lot sampling increases WIP (3)

+Helpful guidelines/tools outweigh inflexibility (1)
+Facilitates change (1)
+$.5 million incentive to achieve high reliability (1)

G7 Quality Assurance Representative

-Delays inspection (up to 48 hours) (4)
-Not JIT oriented (or motivated) (4)
-Batch sampling impedes material flow (3)
-Introduces emotion and inconsistency into quality requirements (2)
-Depends on individual QAR (2)
-Duplicates inspection (1)
-Inadequate technical training (1)
-Increases Material Review Board cycle time (1)
-Excessive audits/requirements (1)

+Provides interpretation/guidance (8)
+Good resource to identify problems (1)

G8 Cost Accounting Standards

-Complex procedures inhibit development of flexible workers (6)
-Compliance costs outweigh benefits (3)
-Outdated standards, can't be changed (2)
-Restrictive inventory controls (2)
-Not conducive to JIT (1)

+Tracks performance/efficiency (1)
+Good inventory control procedures (1)
+Prompted needed investment in computer system (1)

G9 Reporting Requirements

-Quality reports (3)
-Configuration/testing/storage reports (1)
-Requires excessive resources/costs (1)
-Data collection excessive (1)

+CSSR/CSPEC helpful (2)
+No comment (1)

G10 Contract Changes/Modifications

-Lengthy, bureaucratic process (5)
-Engineering changes disrupt production and increases costs (3)
-In-process inspection imposed on commercial product (1)
-Software changes (1)
-Increases overall cycle time (1)
-Increases costs (1)

+No comment (1)

G11 Progress Payments and Controls

-Encourages larger inventories (5)
-Restricts use of material (1)
-JIT threatens progress payments (1)

+Smoothes cash flow (2)
+Promotes cycle time reduction to attain schedule (1)
+Funds start up/facilitization (1)
+Government finances inventories (1)

G12 Socioeconomic Programs

-Occasionally forced to use unreliable vendors (5)
-Inhibits long-term, efficient supplier relationships (3)
-EPA/OSHA requirements restrictive (2)
-EEO requirements result in less qualified workers (2)
-EPA/OSHA requirements conflict with mil-specs (1)
-Restrictive use of foreign suppliers (1)
-Limits contractor's flexibility (1)

+Small businesses are more service oriented (2)
+No comment provided (1)

(NOTE: Multiple responses given)

G13 Subcontracting Policy

-Increases proposal and purchasing cycle time (5)
-Competition prevents close supplier relationships (3)
-Promotes use of too many vendors (2)
-Low-bid philosophy sacrifices quality (1)
-Single sourcing requires extensive documentation (1)
-Promotes buying all material up front (1)
-Source selections too restrictive (1)
-Intracompany transfers difficult (1)

+Prompts new business practices (1)
+No comment provided (1)

G14 Govt. Specified/Approved Sources

-Mil-spec parts increase cycle time and costs (3)
-Forced use of less reliable vendors (3)
-Contractor lacks control over source development (2)
-Restricts sources (2)
-Cannot use better, commercial parts (2)
-Hard to develop new sources (1)

+Easier to get quality parts (1)

G15 Cost/Pricing Data

-JIT increases risk of defective pricing accusation (2)
-Increases proposal cycle time (2)
-Very costly in terms of manpower and dollars (2)
-Demotivates contractor to take risks (1)

None

G16 Govt. Audits/Reviews

-Disrupts material flow due to over compliance (5)
-Decreases productivity, takes time from regular duties (5)
-Costly to provide (3)
-Increases proposal cycle time (1)
-Penalizes cost reduction efforts (1)
-Prompts negative attitudes (1)
-Efforts focused on documentation instead of production issues (1)

None

(NOTE: Multiple responses provided)

G17 Defense Materials/Priorities Systems

-Low priority rating (1)
-Occasionally interferes with purchased parts (1)
-JIT does not recognize priorities (1)

+Increases priority for scarce parts (2)
+Positive schedule impact-internal and vendor (1)

G18 Contract Delivery Schedule

-Customer does not permit early/partial deliveries (3)
-Inefficient schedule, spread out over entire year (2)
-Insufficient lead time provided (1)
-Disrupts internal production schedule (1)
-No comment provided (1)

+Partial/early deliveries permitted (2)
+Drives entire operation (2)
+Provides firm demand (1)
+Incentive provided to meet schedule (1)
+Promotes throughput reduction (1)

G19 Profit Policy

-Discourages capital investment (2)
-Rewards inefficiency, not risk (2)
-JIT risks defective pricing claim (1)
-Encourages short-term, not long-term, cost reduction efforts (1)
-Government-Owned Contractor-Operated plants cannot bring in commercial work to increase efficiency (1)
-Makes negotiations difficult (1)
Govt. doesn't adequately recognize need for profit (1)

+Low profits motivate JIT efforts (4)
+Fixed-Price-Incentive contract encourages JIT activities (1)

IMPACT OF CONTRACTING PRACTICES ON PURCHASING

Negative Assessments	Positive Assessments
G1 Government Furnished Property	
-Obtaining consent for use increases purchasing cycle (3)	+Provides dedicated equipment (1)
-Late or defective govt. property increases cycle time (2)	+Improves quality (1)
-Govt. tool available but not permitted to use it (1)	
G2 Mil-Standards	
-Increases purchasing cycle time (5)	+Provides standardized, well defined requirements (4)
-Limits availability of suppliers (3)	+Improves quality (2)
-Suppliers have difficulty understanding and complying with mil-stds (3)	+no comment provided (1)
-Tied to outmoded technology (1)	
G3 Govt. Control over Specifications	
-Restricts ability to make changes (4)	+Enhances reliability (1)
-Lengthy approval process increases purchasing cycle time (4)	+Everyone subject to same controls (1)
-Causes difficult relations and excessive documentation (1)	+No comment provided (1)
-Minor deviations greatly increase cycle time (1)	
-Forces contractors to use outmoded technology (1)	
-Increases lead time of purchased parts (1)	
-Specification changes disrupt suppliers (1)	
G4 Engineering Change Procedures	
-Lengthy approval process delays purchasing cycle (11)	None
-Making changes is very difficult (1)	
G5 Value Engineering Program	
-Approval time too long (2)	+Future use considered (2)
	+Beneficial to internal and supplier activities (1)
	+Reduces costs (1)

G6 Contract Quality Requirements

-Interpretation differences make buying difficult (3)
-Adds more costs/time than benefits (3)
-Restricts ability to make changes (1)
-Minor discrepancies cause major delays of incoming materials (1)
-Makes sourcing more difficult (1)
-Soldering specs cause problems (1)
-Mil-specs applied to suppliers are lower than system specs contractor must meet (1)
-Drive suppliers' prices up (1)
-No comment provided (2)

+Increases supplier quality (2)
+Provides helpful guidelines (1)

G7 Quality Assurance Representative

-Causes delays in inspection (5)
-Delays Material Review Board actions (2)
-Not technically capable (1)

+Vendor approval (1)

G8 Cost Accounting Standards

-Increases documentation requirements and slows procurement (2)
-Compliance is costly (1)
-Restricts interdivisional transfer purchases (1)
-Internal system not good (1)
-No comment provided (2)

+Provides guidelines and standards (2)

G9 Reporting Requirements

-Overkill, increases cycle time/costs (4)
-Takes resources that could be more productively used (1)
-Report on single sourcing discourages its use (1)
-No comment provided (1)

+Increases customer's visibility (1)

G10 Contract Changes/Modifications

-Cause procurement delays (2)
-Quantity changes disrupt procurement (1)
-Revision changes disrupts suppliers and increases purchase cycle (1)
-Causes obsolescence problems (1)
-Insufficient lead time (1)
-No comment provided (1)

+Makes needed corrections even though impacts schedule and costs (1)

G11 Progress Payments and Controls

-Encourages inventory buildup (1)
-Demotivator for JIT (1)

+Flow down to subcontractors helps get material flowing faster (4)
+Government finances required inventories (2)
+Improves cash flow (1)

G12 Socioeconomic Programs

-Contractors forced to go to other than best producers (5)
-Increases purchasing cycle time (2)
-OSHA adversely impacts suppliers (2)
-Restricts use of foreign suppliers (2)
-Prompts increase of supplier base (1)
(NOTE: Multiple responses given)

+Small businesses and small and disadvantaged businesses supportive of JIT (5)
+No comment provided (1)

G13 Subcontracting Policy

-Multiple sourcing/competitive bidding reqts. impede long-term relationships with single sources (5)
-Increases cycle time (2)
-Forces some bad business practices on contractor (1)
-Low bidder mentality causes quality problems (1)
-Mil-spec producers not responsive (1)
-Disagreements between contractor and contract administration office (1)
-No comment provided (1)

+Standardizes procedures (1)
+Make-buy decision gives lever to purchasing (1)

G14 Govt. Specified/Approved Sources

-Directed sources sometimes uncooperative, overloaded (3)
-Qualified parts list items not readily available (2)
-Locks contractors into nonstandard parts/obsolete technology (2)

+Simplifies source selection (2)

G15 Cost/Pricing Data

-Hard to track/deep current (1)
-Data requirements increase proposal cycle time (1)
-JIT risks defective pricing claim (1)

+Provides useful information but at high costs (2)
+Encourages early quotes/firm prices (1)

G16 Govt. Audits/Reviews

-Prolonged audits increase cycle time by delaying program start up (4) -Audits take excessive time, draining JIT purchasing activities (4) -Prompts unhealthy attitude (paranoia, distrust, too much focus on documentation) (3) -Decreases productivity (1) -Too many uncoordinated audits duplicate and waste effort (1)	None

G17 Defense Materials/Priorities Systems

-Low rating (4) -Commercial/government mix yields more problems than benefits (1)	+Improves supplier deliveries (3) +High rating helps (2) +Mixed benefit, mostly positive (1)

G18 Contract Delivery Schedule

-Schedules unrealistic, insufficient lead time (5) -Insufficient lead time so contractor has to procure at contractor's risk (2) -No comment provided (1)	+Provides firm schedule to order to (3) +Flexible delivery schedule provided (1) +No comment provided (1)

G19 Profit Policy

-Low profits discourage independent research and development (1) -Too low for risk (1)	None

RELATIVE FREEDOM TO CONDUCT JIT PRODUCTION ACTIVITIES (RESTRICTIONS CITED BY RESPONDENTS)

OF1 Arranging the plant layout to minimize the distance material travels.

-Centralized quality inspection requirements (2)
-OSHA/EPA controls (2)
-Government property/inventory controls (1)
-Lack of funds due to low profitability (1)

(Multiple responses provided)

OF2 Dedicated equipment to facilitate material flow.

-Government equipment available, use restricted by customer (6)
-Low profit restricts capital investment (2)
-No funding available (govt. or contractor) (2)
-Reluctance to duplicate tooling (1)
-No comment provided (2)

OF3 Group Technology.

-Program specific test equipment (1)
-No comment provided (1)

OF4 Focused Factory.

-Capital investment restricted by low profit (2)
-No control over Quality Assurance function (1)
-Mil-standards restrict it (1)
-No control over incoming inspection (1)

OF5 Development of cross-trained, flexible workers.

-Required separation of quality and production functions restricts use of certified operators (6)
-Mil-standard certification requirements are cost prohibitive (5)
-Cost Accounting Standards (1)
-Soldering inspection requirements (1)
-No comment provided (1)

OF6 Use of Quality Circles or similar activities to involve workers in quality/process improvement.

No restrictions mentioned

OF7 Use of Statistical Process Control.

-Lack freedom to make changes (2)
-In-plant Mil-Q-9858 system not wholly compatible (2)
-100% inspection requirement not compatible with SPC philosophy (1)

OF8 Stop production line when abnormal or defective products or conditions are detected.

-Contract schedule pressure prompts work around (5)
-Line stoppage invites customer involvement (1)

OF9 Make production workers responsible for quality, including inspection.

-Resistance to certified operators (QA inspection/documentation required) (18)
-Quality inspection points (1)
-Job descriptions (1)
-Union restriction (1)

OF10 Aggressive preventive maintenance program.

-No funding for preventive maintenance of antiquated government provided test racks (1)
-Restricted government furnished property (1)
-No funding to refurbish government property (1)

OF11 Improving processing capability and maintainability of equipment.

-Controls over government owned equipment restricts improvement(5)
-No funding available due to restricted overhead budget (3)
-Government approval to make changes takes too long (3)
-Mil-standards impose controls that restricts improvement (1)
-Documentation restricts improvement (1)
-Contract requirement not to change test stations (custom controlled software and hardware) (1)

OF12 Operator involvement in routine preventive maintenance/inspection.

-Overhead charges restrict it (1)
-Must be QA certified to perform calibration (1)
-Operators restricted from some preventive maintenance activities (1)

OF13 Setup time reduction.

-Government furnished equipment (1)

OF14 Lot size or batch reduction.

-Small lots increase documentation (3)
-Batched lot acceptance tests (1)
Contract delivery schedule (1)

OF15 Installation of a "pull" production control system.

-Government restricts purchasing from buying effectively (1)
-Paperwork requirements (1)
-DCAA resistance to MRP II (1)

OF16 Work-In-Process inventory reduction.

-Batch testing and burn-in requirement increases WIP (1)
-Progress payments prompt higher inventories (1)
-Engineering change proposal cycle (1)
-Cycle time for Material Review Board actions/Engineering deviations (1)

OF17 Achieving a linear or drum beat production rate.

-Contract delivery schedule restricts it (5)
-Inspection requirements (1)

OF18 Establishing a linear contract delivery schedule.

-Contract schedule was not negotiable (4)
-Customer restricts GBL shipments (2)
-Customer needs preclude linear schedule (2)
-Customer provides shipping containers late (1)
-Full lot sizes required for lot acceptance test (1)
-Government calculation of delinquent delivery status (1)
-Small contract (1)
-No comment provided (2)

OF19 Changing government contracting requirements not supportive of JIT.

-Customer not responsive (13)
-Tried with mixed success, mostly negative (3)
-Easier to work around problem than change constraint (2)
-Contractor's perceptions that it can't be done (2)
-Unwilling to risk challenging customer (1)
-Commerciality test for same basic product, sometimes commercial and sometimes not (1)
-Customer's procedures inadequate (1)
-No comment provided (8)

OF20 Reduction of administrative and paperwork requirements.

-Government requires documentation (22)
-Company policy requires documentation even if contract doesn't require it (1)
-Management information system cannot be changed (1)
-Documentation dictates process (1)
-Perception that paperwork cannot be reduced (1)
-No comment provided (5)

RELATIVE FREEDOM TO CONDUCT JIT PURCHASING ACTIVITIES (RESTRICTIONS CITED BY RESPONDENTS)

PF1 Working with suppliers to achieve Total Quality Control.

-No comment provided (2)

PF2 Helping Suppliers apply JIT principles to their own operations.

-Competitive bidding requirement (no preferential treatment) (1)
-No comment provided (1)

PF3 Reduction of supplier base to include only the very best suppliers.

-Multiple sourcing/competitive bidding requirements (4)
-Restricted to government approved suppliers (2)
-Best vendors refuse government work (1)
-Product design restricts vendors(1)
-Contract administration and auditors question higher prices of using better vendors (1)
-Requirement to give 5% of contract price to small and disadvantage businesses(1)
-No comment provided (3)

(NOTE: Multiple responses given)

PF4 Establishment of long-term partnerships/contracts with preferred suppliers.

-Government contracts are short-term (3)
-Competitive bidding requirements (2)
-Fear that auditors will view then as indications of collusion/fraud (2)
-Cannot combine requirements of several contracts together (1)
-No comment provided (2)

PF5 Single sourcing.

-Multiple sourcing/competitive bidding requirement precludes it (13)
-Single sourcing requires extensive documentation (2)
-No comment provided (3)

PF6 Preference for local or geographically close suppliers.

-Qualified parts lists (high tech parts) -- no local suppliers qualified (4)
-Competition requires award to low bidder (1)
-No comment provided (2)

PF7 Supplier JIT deliveries.

-All material purchased up front (1)
-Mil-spec houses have minimum buys (1)
-Quality inspection requirements (1)
-Dual sourcing and paperwork requirements (1)

PF8 Minimization of receiving requirements.

-Incoming inspection and documentation required (15)
-Contracting officer requires additional inspections beyond mil-spec and contract requirements (1)
-No comment provided (2)

PF9 Reduction of administrative and paperwork requirements.

-Government requires paper audit trails (13)
-Restricted by contractor's own documentation policy to ensure compliance with government documentation requirements (3)
-No comment provided (4)

BIOGRAPHICAL SKETCH

Carl Ross Templin [redacted]. He attended public schools in South Salt Lake and Midvale, Utah, graduating in 1969 from Hillcrest High School in the Jordan School District. He attended Brigham Young University for one semester, but then interrupted his studies in 1970 to serve a two-year mission for his church in Colombia and Venezuela. He returned to Brigham Young University in 1972 and graduated Summa Cum Laude in 1975 with a Bachelor of Arts degree in Humanities. He received a commission in the United States Air Force. He has served as a missile launch officer, a production officer, and as an acquisition contracting officer. He is currently a major and is assigned to the Air Force Institute of Technology. His military decorations include the Air Force Meritorious Service Medal, the Air Force Commendation Medal, and the Combat Readiness Medal. He received his Master of Business Administration from the University of Wyoming in 1979. During his tenure at Arizona State University, he was elected to the Sigma Iota Epsilon honorary management society, received a Purchasing Management Association of Arizona Scholarship, and was selected as a National Association of Purchasing Management Fellow for 1988-1989. Upon completion of his Ph.D. he will join the faculty of the Air Force Institute of Technology, School of Systems and Logistics.